Armsby, Pauline M, 1996.
An Intelligent Pedestrian Device:
Social, Psychological and Other Issues of Feasibility.
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14

AN INTELLIGENT PEDESTRIAN DEVICE:

SOCIAL, PSYCHOLOGICAL AND OTHER ISSUES OF FEASIBILITY

Pauline M. Armsby BA (hons) MPhil

Thesis submitted in partial fulfilment for the award of

DOCTOR OF PHILOSOPHY

MIDDLESEX UNIVERSITY

May, 1996.

Acknowledgements.

I would especially like to acknowledge my Director of Studies and mentor, Professor Christopher Wright for the original idea of an Intelligent Pedestrian Device and for the guidance he has given me. I would also like to thank Professor David Marks for his assistance, Mr Christopher Abbess for his patient help with data analysis, Mr Keith Johnson for his technical support in data collection, Ms Tina Roberts for her assistance in data retrieval and Mr Tharatman Narenthran who completed a student placement project on the technological feasibility of an Intelligent Pedestrian Device.

I could not have completed this work without the practical support and love that I received from my mother, sister, partner and two daughters. Also, there are numerous other people who have helped me develop both my work and the self confidence required to do it. Thankyou.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

AN INTELLIGENT PEDESTRIAN DEVICE:

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Doctor of Philosophy Thesis submitted by

P. M. ARMSBY

ABSTRACT

An Intelligent Pedestrian Device (IPD) is a new concept in pedestrian safety. It is defined as a microprocessor based information device which detects the approach of oncoming vehicles and informs the pedestrian whether or not it is safe to cross. IPDs could be portable or fixed to a roadside station. They could help reduce pedestrian accidents, which cost £2681 million in the UK in 1994. This study aims to assess whether the concept is socially acceptable and what the design criteria might be.

A study of social acceptance involved group interviews of 5-10 participants with 84 pedestrians in five categories: adults aged 18-60, elderly aged 65+, visually restricted, parents of children aged 5-9 and children aged 10-14. The results suggest that vulnerable pedestrians are more positive about the device than the more able-bodied. Theories that may help explain this are discussed and it is concluded that, with education and marketing, the IPD could gain a degree of social acceptance.

Observation of more than 900 pedestrian crossing movements at four different sites showed a range of behaviours, and that people often take risks in order to reduce delay. IPDs will require pedestrians to change some of their behaviours, especially those that are risky.

Legal acceptance will demand high levels of costly product research and development, and a portable device will not be technologically feasible until well into the next century. However, the wider social benefits of IPDs may be worth the costs.

An outline of design criteria for basic and sophisticated portable IPDs is given, and alternative functions are suggested. It is recommended that further work concentrate on developing software and hardware for fixed modes of IPD. It is concluded that, ultimately, acceptance will probably depend on whether Government decides that the IPD has a place in the road environment of the future.

PART 1

INTRODUCTION

Chapter 1. Introduction

Chapter 2. The Pedestrian Environment and the Intelligent Pedestrian Device (IPD)

CHAPTER 1. INTRODUCTION

1.0 AIM OF THE WORK

1.1 WHAT IS AN INTELLIGENT PEDESTRIAN DEVICE (IPD)

1.2 THE NEED FOR AN IPD - WHO COULD IT HELP?

1.3 OUTLINE OF THE THESIS

CHAPTER 1. INTRODUCTION

1.0 AIM OF THE WORK

This work forms the initial stages of a feasibility study for a microprocessor based information device, which could detect the approach of oncoming vehicles and signal the pedestrian user whether or not a crossing may safely be made. The device is referred to as an Intelligent Pedestrian Device or IPD.

Issues of feasibility were investigated in two main areas as follows: social acceptance and human factors. In addition, legal implications, device technology, and finally costs and benefits were briefly overviewed. The aim was to assess the possibilities and constraints in each area, and if possible develop design criteria.

Emphasis was placed on human factors because one of the primary aims of this work was to understand how human behaviour might affect the design and use of the IPD. A study of the social acceptance of an IPD was carried out because there is little point in developing an innovation that the public do not want and it would help uncover perceptions and attitudes that might affect purchase or use.

Ergonomic and human factors are crucial for the efficient design of systems to be used by humans, and hence should be considered at the very earliest stages of design (Mc Cormick, 1976). There are two main reasons for this. Firstly, in order to discover what a device must be capable of doing in a task it is useful to know how humans successfully achieve the same task. Secondly, to prevent human errors from occurring at the human interface level, designs must take into consideration human capacities and limitations in attending, interpreting and reacting.

The other areas of feasibility, namely legal implications, device technology, and costs and benefits, are briefly investigated in order to uncover the possibilities and major stumbling blocks. It is of concern whether any laws on pedestrian movement or consumer rights would affect usage, whether the necessary technology exists (and in particular, which of the possible forms of signal transmission would be most efficient in gathering the information required) and what would be the costs and benefits.

To summarise, the aims of the work were to:

- develop preliminary specifications for the IPD based on knowledge about human behaviour,
- uncover difficulties and possibilities in the other areas of work that might affect designs for the IPD,
- make an overall assessment of the current and likely future feasibility of the IPD.

1.1 WHAT IS AN INTELLIGENT PEDESTRIAN DEVICE (IPD)?

A basic outline of the IPD was required as a starting point for investigations (Armsby, 1988). Two types of IPD were envisaged:

1. PORTABLE - carried by individual pedestrians,
2. FIXED - attached to a roadside station.

Both types would monitor traffic movement in relation to the user's location and give him or her information about whether it was safe to cross the road. A personal portable device would give maximum freedom of movement. It would enable users to cross the road where and when it suited them, provided it was safe to do so.

By contrast, fixed devices would be built into the road environment, for example at an existing pedestrian crossing facility that allows pedestrians a right of way phase, or it could stand alone. When attached to an existing crossing facility, i.e. a pelican crossing, zebra crossing or traffic lights with a pedestrian phase, it would supplement the existing system.

Fixed stand-alone IPDs could be situated at places that are convenient for pedestrians, e.g. where a crossing warden is required or at traffic lights with no pedestrian phase. All fixed IPDs would advise when a safe crossing time was available.

Several different modes of operation for portable and fixed IPDs were envisaged. These were:

i. ACTIVE - constantly monitors and advises the user about threatening objects.

ii. PASSIVE - responds only to a user's request for information on status regarding threatening objects.

And on another level of complexity IPDs can be:

a. SELECTIVE - senses user's imminent road crossing and advises on threatening objects only when the user attempts to make a crossing.

b. NON-SELECTIVE - assesses all objects of potential threat to the user regardless of whether or not they are on the road or the user wishes to cross the road.

Portable and fixed IPDs can be active or passive, and selective or non-selective. The various combinations of type and mode could produce a number of different models of IPD. This work investigated the concepts behind the various types and modes to assess which were the most practical. It did not evaluate in detail every variant.

1.2 THE NEED FOR AN IPD - WHO COULD IT HELP?

One specific group of people who would benefit particularly from IPDs would be the visually impaired. The improvement in mobility that an IPD would afford this group would effectively change their way of life.

Another group that would benefit particularly would be the physically impaired. By means of a relatively simple change in the algorithm used to decide on when to give the cross signal, a longer cross time could be allowed. The use of IPDs might therefore result in increased mobility for these groups of people.

The elderly and children lack certain skills and are also vulnerable; elderly people's skills often decline. Portable IPDs could fill the skills gap, and help prevent accidents.

Even the least vulnerable pedestrians may benefit from using a portable IPD. Accidents can and do happen to all types of people. In 1994 there were 16,738 pedestrian casualties in the 20-59 age group. This is over one third of the total pedestrian casualties for that year (Department of Transport, 1995a).

All pedestrians fall into the vulnerable road user (VRU) category. In 1987 the Government set a target of reducing casualties by a third by the year 2000 (Department of Transport, 1995b). Their strategy to achieve this focusses particularly on VRUs, and this research will be relevant over the longer term.

1.3 OUTLINE OF THE THESIS

The thesis is divided into five parts. Part one (including this chapter) provides a general introduction. Its aim is to introduce the reader to the IPD concept and outline of the scope of the work.

Part two includes three chapters on social acceptance. It begins by discussing consumer attitudes and beliefs as they specifically relate to safety equipment. Next presented are details of an interview study carried out to ascertain peoples' initial attitudes towards the IPD. Part two aims to discover the likely effect of social and personal attitudes on purchase and usage.

Part three consists of four chapters on pedestrians' road crossing behaviour. It begins by summarising previous research on pedestrian behaviour and the interaction between drivers and pedestrians. This information is presented as a prelude to an observational study of pedestrian crossing behaviour, which was undertaken firstly to help understand how people might respond to hypothetical IPDs, and secondly to help discover the most important features of pedestrian behaviour that need to be taken into consideration in its design.

Part four consists of one chapter that draws together information on the other non-behavioural aspects of feasibility that affect implementation of the IPD, i.e.. legal implications, technological possibilities and costs and benefits. It is followed by a concluding chapter which outlines design criteria for the IPD, limitations, and problems that remain to be solved.

CHAPTER 2. THE PEDESTRIAN ENVIRONMENT AND THE INTELLIGENT PEDESTRIAN DEVICE (IPD)

2.0 INTRODUCTION

2.1 PEDESTRIANS' PROBLEMS IN THE PRESENT ENVIRONMENT

- 2.1.1 Existing Pedestrian Crossing Facilities
- 2.1.2 Mobility Handicapped Pedestrians
- 2 1.3 Traffic Flow, Noise and Pollution
- 2.1 4 Pedestrian Accidents

2.2 BENEFITS OF AN IPD

2.3 THE ENVIRONMENT OF THE FUTURE AND THE IPD

CHAPTER 2. THE PEDESTRIAN ENVIRONMENT AND THE INTELLIGENT PEDESTRIAN DEVICE (IPD)

2.0 INTRODUCTION

This chapter describes the physical road environment for pedestrians, including road crossing facilities, and comments on its effect on pedestrians. It aims to show that the current (and probably the future) road environment is unfriendly to pedestrians, and that IPDs could improve the situation in a number of ways.

2.1 PEDESTRIANS' PROBLEMS IN THE PRESENT ENVIRONMENT.

Most roads have several functions. Pedestrians need, for example, a safe and pleasant environment. Conflicts occur when competing demands on a road cannot be accommodated. The needs of the driver 'conflict' with the needs of the pedestrians to be able to cross the road safely without having to walk undue extra distance or incur undue delay (Ward et al, 1994). Roads are categorised and managed according to a hierarchy. Table 1 shows the predominant activities and the 'expected' pedestrian movement at the five hierarchically classified groups of urban roads. (Department of Transport, 1987a).

Unfortunately, although pedestrians have a natural right to use the highway, roads are often not designed primarily with pedestrians' safety and convenience needs in mind. It can be argued that pedestrians do not take risks, they are exposed to them. 'Much more risk evaluation occurs ... where the planners are, the designers, the managers, the authorities that make decisions in lieu of millions of others' (Yates, 1992), and yet pedestrians are still exposed to considerable risk. A recent study (Ward et al, 1994.) showed that '16% of the walking and 15% of the crossings that take place on district distributors produce nearly 50% of the casualties'. There is a mismatch between what designers expect and what pedestrians can cope with.

Table 1 *Predominant Activity and Pedestrian Movement at the Five Hierarchically Classified Groups of Urban Roads.* *

	Predominant Activity	**Pedestrian Movement**
Pedestrian Streets	Walking, meeting, trading	Complete freedom
Access Roads	Walking, vehicle access, delivery of goods and servicing of premises. Slow moving vehicles	Considerable freedom with crossing at random
Local Distributors	Vehicle movements near beginning or end of all journeys. Bus stops	Controlled with channelised e.g. zebra crossings
District Distributors	Medium distance traffic to primary network. Public transport. All through traffic with respect to environmental areas	Minimum pedestrian activity and positive measures for their safety
Primary Distributors	Fast moving long distance traffic. No pedestrian or frontage access	Nil-complete segregation between vehicles and peds

* Abridged from Department of Transport. Roads and Traffic in Urban Areas. 1987a. p33.

2.1.1 Existing Pedestrian Crossing Facilities

There are several types of pedestrian crossing facility. The following table (2) summarises the types of facility available and the factors to be considered when determining which is the most appropriate at any one location.

Each facility has different advantages and disadvantages for the pedestrian. However, with the exception of the school crossing patrol, all the facilities are permanently sited where Local Authorities think they are needed. This means that pedestrian safety is catered for at well defined places of potential danger or need. However, an individual pedestrian's most convenient crossing place may be elsewhere.

Table 2 *Pedestrian Crossing Facilities and Factors Determining their Appropriateness at any One Location.* *

PELICAN CROSSING	High pedestrian/ vehicle conflict exists. Heavy pedestrian flow. High speed vehicles. Unusual sites. Large proportion of infirm pedestrians.
PEDESTRIAN STAGES AT CONTROLLED JUNCTION	High pedestrian/vehicle conflict occurs, and the vehicle movements are difficult for pedestrians to anticipate.
ZEBRA CROSSING	High pedestrian/vehicle conflict exists. Traffic not too heavy or fast moving. Pedestrian flow not too high. No unusual traffic movements.
SCHOOL CROSSING PATROL	Concentrated movement of children occurs at specific times, and so particular pedestrian/vehicle conflict exists.
REFUGE	Wide carriageway and high vehicle speeds create 'insecurity' for pedestrian.
FOOTBRIDGE AND SUBWAY	A pedestrian demand exists but conventional surface level facilities are not considered practicable due to high traffic flows, speeds or road layout.

*Abridged from A Step Ahead. Association of Metropolitan Authorities. 1989. pp 18-19.

There is evidence that some people would prefer more pedestrian facilities (National Consumer Council, 1987). However, it is not possible to place a pedestrian facility at every location where there is sometimes a need.

Of the existing facilities, pelican and zebra crossings are the most widely available and have well defined operating characteristics (see for example, Department of Environment, 1973; Department of Transport, 1980, 1981, 1987b). Studies have been done to test various alterations to the pelican crossing with the aim of increasing safety levels (Robertson, 1976; Skelton et al., 1976; Landles, 1982; Pye, 1983). Other studies have sought to assess their relative safety (Marinus, 1976; Inwood and Grayson, 1979;

Khasnabis et al., 1982; Essex County Council, 1987). However, users still have complaints about the crossing facilities available (Wilson and Rennie, 1980; Todd and Walker, 1980; National Consumer Council, 1987), because they are perceived to be dangerous.

Footbridges and subways are particularly unpopular. Atkins work (1989) shows that subways are a design nightmare. They are often badly maintained enclosed spaces, with poor visibility and no surveillance.

In addition, subways and footbridges can require detours. Evidence suggests that pedestrians are sometimes unwilling to make detours, (Older and Grayson, 1974; Hunt and Williams, 1982) Perhaps as a consequence of this, the pedestrian accident rates within 50 metres of existing facilities are abnormally high (Department of Transport, 1995a). Older and Grayson show that adult crossing strategies try to reduce the amount of delay experienced during a journey. Also, Hunt and Griffiths (1988) showed that to avoid delay pedestrians using pelican crossings cross in gaps in traffic, and this may result in them being at higher risk, as vehicle drivers will probably be directing at least some of their concentration on the traffic signals. Fixed facilities can cause longer delays than crossing at other places. This is despite Hunt's (1990) finding that pedestrians allow an extra 1-2 seconds for gaps accepted at places with no recognised crossing facility, because vehicles are not required to yield right of way.

Finally, pedestrianisation helps avoid problems by segregation. Edinburgh intends using pedestrianisation to help make a pedestrian friendly city, 'to turn the tide of car culture and improve the quality of life on Edinburgh's streets' (Baker, 1994). Unfortunately, segregation is unlikely to affect more than a small proportion of the road environment, and hence will not solve many of the problems pedestrians face negotiating the road environment.

2.1.2 Mobility Handicapped Pedestrians

Many people will have some kind of mobility handicap at some time in their lives, be it a bad back, a broken leg or reduced ability to move around caused by the ageing process.

Others are permanently handicapped either physically or mentally. Attaining mobility for everyone is a big problem (TRANSNET, 1990). Oxley (1989) quotes a figure of 14 per cent of the British population as having some degree of disablement. Many, he says, rely on walking (or wheelchairs) and public transport (or special services) because they cannot afford a car. Mobility handicaps vary greatly in type and severity. This makes it very difficult (and expensive) for Government and Local Authorities to make the pedestrian environment accessible to everyone.

The Government has a Disability Unit at the Department of Transport which aims 'to create an impetus for change and the means by which improvement (can) be made throughout the transport spectrum- from the pedestrian environment to personal mobility...' (Frye, 1989). Some advances have been made; for example, tactile surfaces for blind people have been developed. The Institute for Highways and Transportation have comprehensive 'Guidelines for Providing for People with Mobility Handicap' (IHT, 1986; Mitchell, 1990).

Several devices for mobility handicapped pedestrians at existing traffic light controlled crossings have been investigated (Anon, 1980; Mc Cann and Cross, 1982; Anon, 1985). One device under investigation with the Transport Research Laboratory is an electronic radio frequency tag which would be carried by disabled people. The tag would be read by an antenna at a crossing place and this would activate the traffic light stop signal (Armsby and Wright, 1989a; Anon, 1990).

Another innovation is the 'Puffin' (Pedestrian User Friendly Intelligent) crossing, which will gradually replace existing pelican crossings and crossings at signalled junctions. The puffin has an infra-red detector that monitors both the presence of pedestrians waiting to cross and those in mid crossing, and if users no longer need a pedestrian phase or take a long time to cross, it can cause the red phase to be cancelled or extended (Davies, 1992; Dept. of Transport, 1992; 1993a). It will benefit particularly those users with mobility handicaps.

It is perhaps visually handicapped people who have the greatest difficulty in walking the streets. Efforts have been made to augment existing road crossing facilities with audible and tactile signals at pelican crossings (Dept. of Transport, 1991a; 1991b). However, their mobility is still limited and they are liable to injury from obstacles on the footway itself. For these reasons much research has been done on electronic spatial sensors for the visually impaired (Warren and Strellow, 1985; Gill, 1985, 1986). These are discussed later.

2.1.3 Traffic Volume, Noise and Pollution

Government believes that 'any attempt to impose drastic limitations on mobility in the interests of safety...is almost certainly doomed to failure'. (Department of Transport, p. 23 1987a). Couple this with the increase in population, and this means that we can probably expect a doubling of vehicle numbers between 1995 and 2025. The road traffic accidents and pollution this will cause are a serious public health issue. Despite the Government's strategies to reduce pedestrian casualties (Department of Transport, 1989a; 1989b); Institute of Civil Engineers, 1990) more traffic is bound to exacerbate pedestrians' problems.

The Government has pledged that its 'policies do not include an automatic weighting in favour of mobility at the expense of safety in situations where the two are in conflict ...particularly where the mobility of the motorised road user group is at odds with the safety interests of the vulnerable non-motorised group' (op cit. p 24). But quality of life for vulnerable road users generally is being eroded (Davis, 1992), and children have lost independent mobility and rights (Hillman et al., 1990; Hillman, 1993).

A recent report from the Transport Research Laboratory on (Bly et al., 1995) suggests that people are encouraged to travel short distances by walking and cycling in order to reduce vehicular traffic. But the public are unwilling to give up their cars or their right to use them. Pressure groups like the Pedestrians' Association and Transport 2000 try to educate otherwise, but face an uphill battle in trying to persuade people to put social needs above personal convenience.

The National Consumer Council (1987) found that 37% of pedestrians surveyed believed that 'too much traffic/ busy roads' was one of their main problems. Another survey (Hopkinson and May, 1986) found that a third of pedestrians interviewed rated 'the amount of traffic and associated noise and fumes' as very or quite bothersome.

Increased levels of traffic flow have been shown to affect pedestrians in several ways. Korte and Grant (1980) believe that pedestrians subjected to high levels of traffic, and hence traffic noise, will suffer 'input overload'. Their research shows that this causes various behaviour changes, for example, restricted visual scanning. Not only does this affect quality of life but it may increase the likelihood of accidents.

Increased vehicle flows make it difficult to find an acceptable gap (Tanner, 1951; Ashworth, 1971) and can increase delay, although, delay is also affected by the traffic arrival pattern (Goldschmidt, 1977). Delays are found to strongly depend on the distribution of vehicle platoons, which can form clear gaps in the traffic stream. Delays of more than half a minute frustrate pedestrians (Hunt and Khalil, 1988), and are likely to predispose them to take greater risks when crossing the road. For example, increased traffic volume results in more pedestrians red-walking (Garder, 1989). Also, heavy traffic flow is known to sever communities and suppress pedestrian travel (Taylor, 1992).

2.1.4 Pedestrian Accidents

Most of us are pedestrians, and as such we risk being injured by vehicles. Although exposure varies between different groups (Tobey et al., 1983) the elderly and young children are particularly vulnerable (Dept. of Transport, 1995a; Grayson, 1980; Lawson, 1990; Todd and Walker, 1980; Ward et al, 1994). School Crossing Patrol Wardens (SCPW) 'remain the safest form of crossing for children during the SPCWs' hours of duty' (Saunders, 1989).

Pedestrian casualties account for about one fifth of all road traffic casualties and one third of all road traffic deaths. The number of pedestrian accidents is the most pointed indicator of how unfriendly the road environment is for pedestrians. Walking is the most basic means of transport, open to almost everyone, and yet it entails substantial risks.

Reviews of pedestrian accidents (Golden, 1980; London Accident Analysis Unit, 1986a) have shown the importance of the road environment in helping explain accidents.

Knoblauch (1976) has considered the rural/suburban problem: Hoque and Andreassen (1986) the effect of road class: Maycock and Hall (1984) roundabouts: Polus (1985), London Accident Analysis Unit (1986b) and Mc Donald et al, (1987) junctions: and Herms (1972) and Daly et al, (1991) pedestrian crossing facilities.

Pedestrian accidents have a number of different causes; broadly they can be classified into vehicular, environmental and human, although the causes almost always overlap (Sabey and Taylor, 1980). Education, legislation, engineering remedial work and better highway design can help, but each approach has its limitations. The influence of education is difficult to evaluate and often slow to take effect; legislation is unpopular and costly to enforce, and remedial measures and highway designs often reduce freedom of movement either for the driver, or more importantly, for the pedestrian.

2.2 BENEFITS OF AN IPD.

One recent study (Grayson, 1987) has shown that over the road network in the past 20 years 'the pattern of risk to pedestrians remains much the same.' The new approach offered by IPDs might help change things. Risk would be minimised for road users by supplying them with an aid that could help them cope with their environment. If pedestrians perceive road crossing with an IPD to be less risky, they may feel 'safe' enough to make more and longer journeys on foot. This may encourage a move from using 'unhealthy' motorised modes of transport to 'healthy' alternatives (walking and cycling).

Portable IPDs would help users to make the most efficient use of safe gaps in traffic. This would be an important advantage in societies that are becoming increasingly motorised. Also, it would reduce costs in terms of pedestrian delay (this is discussed further in chapter 10). Fixed stand-alone IPDs at places where there is an appreciable risk of a conflict (e.g.. at a school crossing patrol) could also reduce detours and delays.

Fixed IPDs that work in conjunction with an existing at-grade facility would improve safety by offering pedestrians a safe monitored period at the same time that vehicles are required to stop and give pedestrians priority. This would improve pedestrians' perception of safety and help promote confidence in the facilities. This facility might also prove particularly popular with visually handicapped users as it would provide evidence that any vehicles within a reasonable range had actually stopped for the user. This added level of confidence goes one crucial step further than the infra-red detector outlined above.

Ultimately, a portable IPD would confer much greater freedom, particularly for the disabled. The reduced walking speed of the handicapped pedestrian could be allowed for. In some cases where a detour to an existing facility would result in a reduced delay for an able-bodied pedestrian, a mobility handicapped pedestrian might prefer to conserve his or her energy and wait for a portable IPD to advise that a safe gap was available. The important advantage of the portable IPD is that it gives its user two 'safe' choices: waiting for a safe monitored crossing anywhere on the road network, or going to an existing facility. Indeed the portable IPD would help its user decide which option is usually most expedient on its owner's well used routes.

IPDs should help prevent accidents caused by pedestrians' lack of attention or poor judgement skills. For example, it would compensate for our poor nightime vision, which increases the risk of an accident in darkness (Ward et al. 1994). Other accidents caused by driver error, confusing road layout or vehicle malfunction, could also be reduced as users would not be advised to begin crossing in potentially dangerous situations.

History shows that progress cannot easily be halted (see figure 1). It remains the case that apart from total segregation, vehicles will continue to pose a threat to pedestrian safety.

Figure 1 The Beginnings of the Automobile Association.

> The Automobile Association was formed in 1905. Its aim at the outset was to protect the interests of motorists.... with the object of warning motorists of speed traps ahead! (Nicholson, 1992)

The AA now has a Foundation for Road Safety Research which funds important studies into both driver and pedestrian safety.

2.3 THE ENVIRONMENT OF THE FUTURE AND THE IPD.

The recent report of Bly et al (1995) from the Transport Research Laboratory on 'Future Scenarios for Inland Surface Transport' predicts 'sophisticated flows of information between vehicles and control centres'. This information would mainly benefit drivers, for example, in helping them avoid congestion (DRIVE, 1990; Mc Donald and Lyons, 1996). IPD's should redress the balance and add to the safety of pedestrians provided by vehicle systems.

The report says that 'new technology will have an important role to play in minimising congestion, accidents and injuries, and environmental nuisance, but an efficient and acceptable transport system will depend on appropriate policies as well as new technology'. They suggest that research on the likely effects of new technologies is crucial so that there is clear identification of desirable changes. Some work on the DRIVE project (Carsten and Tight, 1990) is considering the effects of advanced traffic systems on Vulnerable Road Users (VRU's). The report states that 'such systems may have negative safety and mobility effects for VRU's'.

Further research on the likely effects of the portable IPD is undertaken in this thesis, and will be required when a working device becomes available. Whether or not the portable IPD fits into the environment of the future will depend partly on what other 'desirable changes' (and their consequential policy changes) are made, and whether or not they are compatible with IPD usage.

PART 2.

THE SOCIAL ACCEPTANCE OF AN INTELLIGENT PEDESTRIAN DEVICE

Chapter 3 Social Acceptance

Chapter 4 Qualitative Interview Study

Chapter 5 Results, Discussion and Conclusion of the Interview Study

CHAPTER 3. SOCIAL ACCEPTANCE

CHAPTER 3. SOCIAL ACCEPTANCE

3.0 INTRODUCTION

The term 'social acceptance' covers a number of important issues, for example: what level of acceptance of an IPD can be expected? How will societies' major institutions respond? Will people perceive the need for an IPD? Will non-users and drivers be affected? This chapter summarises previous research that could help answer some of these questions.

The first section concentrates on the wider social issues. In section two, factors that might influence the perceived need for new products are outlined. Section three describes conditions that could help build social acceptance. The final section discusses the implications of the foregoing for the IPD, and introduces the next two chapters, in which this author's more specific research on social acceptance is reported.

3.1 WIDER SOCIAL ISSUES

Before new products can be accepted by the individuals in a society, that society's major institutions must consider the wider social impact of the new product. The Consumer Protection Acts (further discussed in chapter 10) provide one framework for doing this. This section outlines what some of these social issues might be.

Starr (1969) reported that 'technological growth has been generally exponential in this century, doubling every 20 years'. His concern was that judicious national decisions should be made about new technological developments to achieve maximum social benefit at minimum social cost. Some studies, however, have shown negative consequences brought about by new technology. Boden (1989a) puts succinctly a note of warning.

> We should remember that the natural world and human society are complex ecosystems, and that technological intervention may have counter-intuitive and damaging effects. For example, if we invent a toxin to kill 99% of the caterpillars who eat our cabbages, the predators who gobble up the caterpillars will all die out and the remaining 1% of caterpillars will have no natural foes - result: no

> cabbages.... In general, then, we should beware of or even deliberately avoid certain prima facie 'improvements', because of the indirect effect they may have on the social fabric.

Murray and Richardson (1989) note that innovations are not always evaluated properly. For example, 'A recent introduction to the field of expert systems makes no reference at all to their implications for society at large'. Unfortunately, new technology can often become deeply integrated into the economic, political and cultural structures of our society before its impact is evident or measurable.

This means we should try to look ahead, and both control the effects of our technological interventions and regulate adverse consequences (Irwin, 1985). There is often uncertainty about the impact of future developments and 'experts' themselves differ in their judgements of safety and risk. For example, Bonsall and May's (1989) evaluation of Route Guidance Systems (RGS) outlines a number of problems.

- although RGS will improve road safety it may cause user distraction
- users may choose to ignore advice given if they think it does not increase their own efficiency
- there may be an environmental impact due to increased exposure
- there may be possible effects on non-users.

And their conclusion is that 'a certain amount of information can, of course, be obtained through pre-production tests, prototype trials and market research but many of the impacts would not become apparent without implementing the system on a significant scale.'

3.2 FACTORS INFLUENCING ATTITUDES TOWARDS NEW PRODUCTS

The following discusses various factors that will influence individuals' perception of need and social acceptance of new products, which in turn will affect whether or not they buy and use them. First, some cultural and environmental issues that could affect attitudes are outlined, and then human attributes that will affect perceived need and acceptance are discussed.

Our culture affects our attitudes. For example, Irwin (op. cit.) notes that culture affects attitudes towards traffic safety; 'American groups tend to accept the importance of the car in future transport policies and, therefore, set themselves the task of "living with the automobile" in the most socially harmonious manner. The British groups, however, argue vehemently in favour of alternative transport technologies'. Taking a wider social view, it can be argued that the dominance of vehicles should be reduced by social and political means, but this seems unlikely to happen.

The environment we inhabit can also affect our experiences, and hence provide an impetus for a change in attitude. Carthy et al's (1993) analysis of the road environment as a jungle where there is survival of the fittest advocates countermeasures to aid the vulnerable pedestrian. We might expect pedestrians to rebel against their worsening conditions, and while there is no evidence yet of a widespread rebellion, there are some initiatives taken by institutions on their behalf. For example, the Transport 2000 (1989) campaign aims to encourage walking by the promotion of pedestrian priority projects, and to keep demand for motorised transport as low as possible.

As technology becomes integrated into our road environments and hence culture, we may be left with the problem of 'how the intelligent vehicle and the smart highway cope with the daft pedestrian' (Wright, 1993). People may perceive the motorists' environment as well suited to technological equipment and be sceptical about pedestrian aids. However, with more experience of technology, pedestrians may accept it more readily in their own environment. Early resistance to new technological equipment can impede social acceptance, but it is often a positive force that shapes technology to consumer needs (Bauer, 1995).

Research into the new RGS for motorists has shown that road user behaviour patterns are resistant to change by technological equipment. Although not primarily safety devices, they may have an impact on safety. One study of RGS advises that 'the key to acceptance and success of RGS lies in the behaviour of drivers' (Watling and Van Vuren, 1993). Drivers may not change from habitually chosen routes, they will respond in different ways to advice, and special attention must be paid to unequipped drivers. Hence, to encourage positive attitudes it will be important to assess existing behaviour patterns.

Turning now to the human attributes that affect the perceived need for new products, assessment of risk may be an important factor. Weinstein (1984) argues that people have optimistic views about the effects of their own actions and attributes on risks. He found that there was no relationship between reported actions and perception of vulnerability to harm: for example, he showed that there was a lack of correspondence between seat belt use and perceived vulnerability in vehicles. It appears that if a risk is controllable (preventable by personal action) then people are unrealistically optimistic about their ability to control it. This is quite normal as it means that they do not feel directed by externalities like, luck or fate (Strickland, 1989). Frank Mc Kenna's (1993) work on this 'illusion of control' suggests that safety measures on the road will be difficult to accept because people do not perceive themselves as needing help.

Research reported here in chapter 6 suggests that pedestrians sometimes have a tendency to abdicate responsibility for crossing the road safely by following other pedestrians (Wagner, 1981). Murray and Richardson (op. cit.) believe that 'human beings do seem to have a tendency to abdicate responsibility to experts' (human or machine), and Boden (1989b) argues that information technology offers us the illusion of control. This research suggests that people would be quite willing to allow technology to guide their behaviour. Other research suggests that people do not feel in control when using technology. Heller (1989) notes that users can be helped to feel in control by allowing them to 'make their own decisions about where and how to operate the technology'. Pedestrian users will make their own decisions because they have ultimate control of their own mobility. Feeling in control when using technology will undoubtedly affect social acceptance.

Hillman et al (1990) notes that confidence in safety devices of any sort affects behaviour. 'People tend to respond in a way that tends to nullify the intended effect of the device'. This means that people will act more riskily if the device makes them feel safer than their 'preferred' level of risk. Krajick (1986) discusses these issues with regard to seat belt use when he says, 'belted in drivers end up bumping off others (e.g. pedestrians, bicyclists and back seat passengers) because they feel safer themselves'. This suggests that even if people do take actions to reduce their risk they will not work. This is rather pessimistic, but it does highlight the need to make people aware of the risks they accept.

3.3 BUILDING SOCIAL ACCEPTANCE.

To build social acceptance of new products it is necessary to take into consideration the factors that influence people's attitudes towards them (described in the previous section). This section outlines some other factors that could help build social acceptance.

Diffusion theory relates to the rate and process by which innovations spread through a population. Nelson and Moffit (1988) outlined six theoretical models which applied to the promotion of safety belt use. These typically emphasize voluntary changes in knowledge, attitudes, beliefs, values and skills. There are four stages involved in accepting innovations, depicted in figure 2.

In the knowledge stage, two types of knowledge necessary for decision making are applied. 'How to' knowledge relates to an awareness of what to do and how to do it. 'Principal' knowledge is the person's initial understanding of how the new product works. In the persuasion stage there is development of an attitude towards the innovation. The following decision to adopt or reject the innovation may depend on the individual's perception of the relative advantage, compatibility, simplicity, trialability and observability of the innovation. Finally, confirmation includes efforts by the individual to seek re-inforcement for the decision. This model explains the process that any innovation will need to go through before it is accepted.

Many scientists are sceptical about the scope for using artificial intelligence in consumer products. Also, people do not always realise the benefits, and hence there are sometimes difficulties in the initial 'knowledge' stage in figure 2. However, Frude (1989) points out, products 'which at one stage appear totally preposterous may, some years later, be seen on the shelf at Woolworth'. Restricting our vision will benefit no-one. Building social acceptance of new products will involve educating people about their benefits.

Figure 2 The Innovation Decision Process.

STAGE

I	II	III		IV
Knowledge ------->	Persuasion ------->	Decision	Adoption -- ----> Rejection	Confirmation
|	|			
'How to' 'Principal'	Compatibility Complexity Trialability Relative Advantage Simplicity			

(From Nelson and Moffit, 1988)

Starr's analysis (op. cit) of our willingness to pay for safety suggests that the influence of authority and dogma can affect the public psychological acceptance of risk. Government have a powerful role in helping people form opinions, and it can use the media to advertise its message e.g. 'clunk click' and 'speed kills'. Hence, government backing for any new product will improve social acceptance.

Slovic et al (1980) suggest that the media can cause considerable bias in risk assessment by reporting dramatic and sensational events, thereby distorting perception of the frequency of their occurrence. Perceived risk often differs from the real risk, and the difference between them causes problems for those who must convince the public that estimates of risk are valid (Kasper,1980). Using the media to make people aware of risks could improve their attitude towards safety aids. Also, clever marketing of products can vastly improve social acceptance and commercial success (Engel et al, 1990).

Willingness to try new things has been shown to depend on socio-economic, personality and communication variables (Engel et al, op.cit). A study by Morgan (1967) on seat belt usage showed that it was related to level of education (not age) and other risk avoidance behaviours. This suggests that there is an open-minded type of person who is prepared to try and use new products. Research to discover which market segments are likely to be more open-minded to the type of new product being developed should help increase usage.

3.4 IMPLICATIONS FOR THE IPD.

The portable IPD is a novel aid for pedestrian safety. Investigation of the wider issues of social acceptance suggests that as it evolves it will be necessary to assess both the direct and the indirect effects that it has on society. This will ensure that the IPD is safe to use and any negative consequences are kept to a minimum.

Acceptance may vary from culture to culture depending partly on attitudes towards other things such as traffic, and the pedestrians' environment will probably help form these attitudes. Our future society will increasingly depend on high technology, and pedestrians may appreciate an aid designed specifically for their needs, rather than rely on in-vehicle intelligent systems. People's readiness to accept IPDs may be affected by other developing technologies like RGS. The issues that affect social acceptance may change quite rapidly.

Conclusions about human attributes that might affect social acceptance of an IPD are less clear. The issues of control of the environment and of technology appear to be central to whether or not pedestrians would buy and use an IPD. It is likely that initially these issues will cause some resistance to the acceptance of the IPD, but there is some evidence that if people recognise their need it could be perceived favourably: research shows that there are always some people who are willing to try out new consumer products, and thereby act as a model. Also, government and the media could be influential in educating the public about the risks of being a pedestrian and the benefits of IPD use. The diffusion model outlined some of the important stages involved when innovations spread through the population. Some of the elements of this model are included in the interview study reported in the following chapters.

To summarise, social acceptance covers a number of important issues. Assessing social acceptance might help discover if resistance to new technology would affect initial perceptions. It was decided that it would be most useful to begin by studying whether or not people said they might buy and use an IPD. Informal discussions with friends, acquaintances and fellow researchers into pedestrian behaviour suggested that able-bodied adult pedestrians would not: people felt more than capable of crossing the road safely using their own judgement, they did not believe that there was a 'reasonable' risk of them being involved in an accident, and they would not trust a device to work more safely or effectively than they could themselves.

In order to throw more light on the problem, in-depth qualitative investigation of pedestrians' attitudes and perceptions was carried out and is described in the following two chapters. Chapter 4 outlines the methods used in the study and chapter 5 gives the results of this work.

CHAPTER 4. QUALITATIVE INTERVIEW STUDY

CHAPTER 4. QUALITATIVE INTERVIEW STUDY

4.0 AIM

The aim of this part of the research was to obtain in-depth information about pedestrians' attitudes and perceptions about the IPD concept. It was hoped that this would allow potential consumers to have an input in designing its features. Also, these findings might help reveal what kinds of marketing and advertising might be most effective.

4 1 GROUP INTERVIEW METHOD AND TECHNIQUES USED

The research began with no theoretical preconceptions or specific hypotheses. It was hoped that these would emerge from the interviews themselves. These are the basic principles of grounded theory (Glaser and Strauss, 1967 in Coolican, 1994).

Small-sample qualitative research is often used to help increase understanding of a market (Gorman and Langmaid, 1988). It can identify ranges of behaviour and explain consumer motivations, usually during the early stages of an investigation.

In particular it is especially well suited to elicit information for new product development as it can:

- find gaps in the market,
- discover reactions to different types of new product,
- help understand consumer opinion to guide product improvement,
- help develop plans for marketing and advertising.

There are two basic qualitative interview methods: group interviews, and individual interviews. The main research method used here was the group interview. Subsidiary methods and different techniques of interviewing were also used. The interviews were video recorded to aid analysis.

A group interview involves a number of people, (approximately 9) who are specially selected according to pre-determined criteria, discussing their attitudes and perceptions about a specific topic. The researcher is present, and facilitates and develops the discussion according to the requirements of the project.

The group interview method was chosen in preference to individual interviews because it has a number of advantages:

- the group environment can highlight any differences between people, thereby illustrating the range of attitudes and behaviour patterns in a relatively short time;
- spontaneity of response and creativity through communication are enhanced in group situations;
- social and cultural influences on attitudes and behaviour are more easily recognised.

The main disadvantage is that it can prevent people with minority opinions from voicing their views. This is especially the case when discussing topics where social norms pressure people into conformity, as is probably the case with issues of road safety, which are often governed by formal norms (i.e. laws), as well as informal ones. Also, where issues of child safety are concerned it may be particularly difficult to resist expressing what are seen as socially acceptable views. This is because our protective 'instinct' towards children makes non-conformists open to censure.

In spite of the above disadvantages the group interview method was selected because it was felt that the advantages outweighed the disadvantages. Individual interviews would undoubtedly have been useful to ensure that minority opinions were exposed, but social and cultural influences revealed by group discussion are just as important. In addition, it was thought that because the IPD is a new product there would be scope for people to raise new and possibly different views.

A final consideration is the financial cost of gathering this information. Individual interviews are far more costly, and the benefits of using them were not judged to be worth the additional cost.

Exactly how much input the researcher should make to a group discussion depends on the interviewing techniques used. A number of techniques are available. The following provides an outline of those used in this study. The interview schedule, as it applies to each group of pedestrians, is discussed in section 4.6.

4 1.1 Non-Directive Technique

The main feature of the non-directive interview technique (Rogers, 1945) is that the interviewer acts as a reflector of the interviewee's comments and opinions. This helps eliminate interviewer bias and allows the researcher to establish what is of immediate interest to the interviewees.

Broad questions are required to start things off. Examples used are:

- What do you like about being a pedestrian?
- What do you dislike about being a pedestrian?

The ensuing discussion between members of the group may be taken in several different directions by the participants, but the interviewer does not add any new information to the discussion. When discussion on one general question subsides, the interviewer may decide to move on to the next question or reflect back the points made.

4.1.2 Critical Incident Technique

The critical incident interview technique is designed to investigate subjects' perceptions in the context of a specific event found to have been crucial to the area of enquiry. It involves asking direct questions about the 'critical incidents' and where possible asking further probing questions to obtain more detailed information.

In a group interview situation this is quite difficult because in-depth information about critical incidents usually comes from individuals. For several reasons, questioning a single member of a group can be harmful to the group activity. In particular, it interrupts the 'free flow' of the group discussion.

Here, the conventional technique was adapted to suit the group situation. The group was asked a critical incident question. For example:

- Have any of you ever been involved in a pedestrian accident?

Individuals then shared their experiences and the group was encouraged to offer examples of other incidents. No single interviewee was probed by the researcher for more detailed information, unless it was necessary to clarify a point. The researcher did however, ask further questions in order to probe the group for more general information.

4.1.3 Focused Technique

The focused interview technique (Merton and Kendall, 1946) involves asking questions related to a particular concrete situation. This is done to investigate in more detail aspects of that situation deemed to be pertinent. The questions encompass all the major areas of enquiry related to the situation being studied, (these having previously been analysed by the researcher).

In this study questions were designed to cover all the major areas of interest for the IPD, focussing on attitudes and perceptions of pedestrian crossing facilities together with hypothetical types and modes of IPD. Examples of questions used are as follows:

- What do you think of the facilities available for pedestrians?
- Do you think people would find it (a model of IPD) useful?

The latter question was asked after (a) a verbal description, (b) an artist's impression and (c) (in one case) a model of the particular type of IPD had been given to the interviewees.

For the most part discussions stemming from questions took place without interruption. However, supplementary questions were asked as necessary in order to develop themes and clear up ambiguities. These were most often directed to the group as a whole, but on occasions it was necessary to ask individuals to clarify specific points. This information was then used to develop group discussion.

4.1.4 Bubble Drawings

Bubble drawings show a situation in which there are people undertaking an activity relevant to the topic under investigation. An empty bubble coming from the mouth of a person represented is left for the respondent to complete with a thought or statement.

This projective technique is quick to perform and generally well received by interviewees. It helps them to sum up their views in one statement, and often helps clarify the range of opinions in a group. It is effective both for adults and children, and facilitates comparisons between them.

For this work a line drawing of a fairly busy road with two pedestrians standing together on the pavement was portrayed, (See appendix 1). One of the pedestrians had a bubble saying:

> "What we really need is one of those pedestrian devices."

The other pedestrian, who looked androgenous was meant to portray the respondent, and had an empty bubble attached.

4.1.5 Projective Drawing

Projective drawing is a versatile technique that offers an unstructured opportunity for subjects to describe or explain their responses to the object or event under investigation. It involves subjects drawing an event or an object within a scenario,and then explaining or interpreting their own drawings. The technique is projective because it is believed that the objects or events in the drawings will be imbued with characteristics or meanings that are derived from subconscious desires or feelings.

This technique is excellent for use with children because they are accustomed to drawing and comfortable with the medium. Also, children can sometimes have difficulty in articulating their ideas and opinions because they are anxious or shy: this technique deflects the attention away from the child. In addition, visual prompts can often stimulate discussion.

Projective drawing was not used with adults because it is time consuming, but it was used with children, to throw light on their understanding and perception of aids for pedestrians. After discussing existing pedestrian aids the children were asked to think up a new aid to help them cross the road and draw a picture of it in use. They were also told that they could write down any notes that they liked on the picture.

If any of the children seemed not to understand, the instructions were repeated in a different way. In addition, the researcher also drew a picture at this time so as not to appear judgemental or anticipatory. A note was made if any child copied another, although no comment was made if this was detected, but this was allowed to pass without comment.

4.2 OTHER METHODS USED

Although the study was predominantly qualitative, some quantitative information was collected on people's attitudes and perceptions. These are detailed below.

4.2.1 Ranking tasks.

There are several techniques in which subjects rank (or rate) a number of relevant aspects of the subject of interest on a scale representing two extremes of a 'dimension of thought' e.g. good-bad, hot-cold. The choice of aspects and dimensions is important, and the techniques vary in how these are chosen. The repertory grid method (Kelly, 1955) incorporates a subjective element, but most do not. In this method the 'dimensions of thought' are devised by the subjects themselves by a process of comparing three items of interest. This is called triadic elicitation (Fransella and Bannister, 1977). Some investigation of this was done in the pilot study with children.

Alternatively, aspects and dimensions can be pre-set. This allows direct comparison of responses between people. The disadvantage lies in presenting people with items that they may not know or understand, and scales that they might not normally use themselves.

In this study the respondents were asked to rank a pre-determined set of pedestrian facilities because (with exception of the fixed and portable IPD) these were familiar. In some cases the name given to the facility might not be familiar (e.g.. refuge = 'island' =

'central area'). However, this problem was overcome by describing each facility before subjects ranked them. The facilities to be ranked were presented in the following order:

Zebra Crossing
Footbridge
Fixed IPD
Pelican Crossing
Refuge
School Crossing Patrol
Portable IPD
Subway
Pedestrianised Street

The scales used were:

Most safe - Least safe
Like using most - Like using least

Pre-pilot studies showed that these 'dimensions of thought' might be central to peoples' thinking about pedestrian crossing facilities. Also, they reflect the trade-off between safety and convenience that has long been recognised in the road safety field.

Ranking tasks are not normally suitable for group interviews because they take time and they interrupt the interview. Hence, completion of the ranking task form (see appendix 2) was left until the end. Also, the task could not be completed properly until all the interviewees had an understanding of the IPD, and this was not achieved until the end of the interview.

4.2.2 Follow-up Questionnaire

Questionnaires are useful for collecting information quickly and efficiently. However, they require considerable care in design and the response rate is not always as high as one might wish. Notwithstanding these difficulties a short questionnaire was deemed to be an appropriate method for this part of the study. The alternative method of calling interviewees back for a follow up session is very costly, and the limited information required did not warrant that expense. Where a questionnaire is used to obtain further information after an interview, there is usually a high response rate.

A follow-up questionnaire was included in the study for three main reasons. Firstly, it would give information about the interviewees opinions, after they had time to assimilate the information about the IPD; secondly, as the information would be privately given, it might encourage respondents to give opinions that they may not have given in the interview; thirdly, it would give the opportunity to compare interviewees' spontaneous responses with their considered opinions.

After each adult interview, subjects were asked to think about what it would be like crossing the road with a portable IPD whenever they crossed the road during the following week They were given a short one page questionnaire in an envelope and asked not to look at it until the end of the week (see appendix 3). The questionnaire would then be completed and returned.

There were three basic items of information requested on the questionnaire:

- what groups of people the respondents felt a portable IPD would be useful for:
- the level of reliability that they thought would be acceptable, and
- the approximate price the respondent would be prepared to pay for the IPD.

There was also a short section for comments.

There is no way of knowing how much, if at all, subjects did actually think about using a portable IPD in the week following their interview. However, it seems reasonable to assume that after one week they would be able to give a considered opinion.

4.3 PILOT STUDY

A pilot study was carried out with two different groups: adults aged 18-60 and children aged 9-11. The main purpose was to test and refine the techniques, and determine whether respondents could envisage clearly what an IPD might be like. Finally, they would uncover any practical difficulties with video recordings.

4.3.1 Subjects

Table 3 shows the number and gender of subjects in each of the pilot groups. The ages in the adult group ranged between approximately 30 and 55, and all were volunteers from the staff at Middlesex University. The children's ages were between 9 and 11, and all were volunteers from a local (Enfield, Middlesex) primary school.

Table 3. *Pilot Interview Study: Males, Females and Total Number of Subjects in Each Group.*

	Number Males	of Females	Subjects Total
Adults aged 18-60	3	7	10
Children aged 9-11	3	3	6
Total	6	10	16

4.3.2 Procedure for Adults

A detailed schedule of the pilot study interview with adults is given in Appendix 4. The following lists the major stages involved in this interview. Many parts of the interview have already been discussed in more detail, and where appropriate these sections are mentioned.

1 INTRODUCTION - to the interview

2 NAME BADGES - are filled in and put on

3 FORM FOR RECORDING PEDESTRIAN'S ROAD USE - is completed

(section 4.5 and appendix 5)

4 NON DIRECTIVE QUESTIONS - related to the problems of being a pedestrian (see section 4.1.1)

5 CRITICAL INCIDENT QUESTIONS - related to near misses and accidents crossing the road (see section 4.1.2)

6 FOCUSSEDQUESTIONS - about pedestrian facilities and the IPD (see section 4.1.3)

7 FOCUSSED QUESTIONS - about fixed and portable IPDs; word bubble (see section 4.1.4)

8 RANKING TASK FORM - (see section 4.2.1 and appendix 2)

9 DEBRIEFING - Any queries, questions or comments

4.3.3 Procedure for Children

The following outlines the main stages in the pilot study interview with children. The complete schedule is in Appendix 6. The general format was almost the same as the adult interviews, except that the methods were simplified and projective drawing was used instead of, or as aid to, some of the other methods.

1 INTRODUCTION - to the interview

2 NAME BADGES - are filled in and put on, ages are given

3 RECORD OF ROAD USE- collected by raising hands

4 NON DIRECTIVE QUESTIONS - related to the problems of being a pedestrian (see section 4.1.1)

5 CRITICAL INCIDENT QUESTIONS - related to near misses and accidents crossing the road (see section 4.1.2); projective drawing (see section 4.1.5)

6 FOCUSSED QUESTIONS - about pedestrian facilities (see section 4.1.3) projective drawing

7 FOCUSSED QUESTIONS - about the portable IPD; projective drawing

8 COMPARISON OF OTHER PEDESTRIAN FACILITIES AND THE IPD - (see section 4.2.1 and appendix 2)

9 FURTHER FOCUSSED QUESTIONS - about the portable IPD

10 DEBRIEFING - Any queries, questions or comments

4 3.4 Implications for the Main Study

There were no problems in ensuring all participants were visible, and that their voices were distinguishable from the other interviewees. The atmosphere of both interviews appeared to be relaxed. As expected, some people talked more than others. The adult group sometimes spontaneously sub-divided into smaller groups and discussed different topics, although it soon reverted back to whole group discussion. Sub-dividing caused problems for video analysis so during the main study, the problem was dealt with by attracting the whole group's attention for a moment by summarising a recent discussion thus 'So you all think xxx ?'

Children did not discuss issues in the same manner as the adults. Each individual's comments were usually directed to the interviewer, with occasional inter-group discussion. However, providing that statements were acknowledged by the interviewer with a neutral statement, the interview continued satisfactorily with the children talking 'through the interviewer'.

Both adults and the children successfully envisaged what IPDs might be like. After descriptions were given, the adult group, and to a lesser extent the child group, asked questions in order to clarify their understanding. Indeed all people displayed considerable interest in discovering as many details as possible about the proposed devices. For the adults the portable IPD was easily understood. It took a little longer to explain fixed types of IPD as there was some confusion between these and existing fixed pedestrian facilities. These difficulties were soon overcome.

The interviews mostly produced useful information. The non-directive,focussed and critical incident interview questions elicited useful information, and also provided a good start to the interview procedure, as they enabled subjects to talk freely about their own experiences. However, because of a certain amount of repetition in questions and answers, it was felt that this part of the interview could be shortened without losing much of importance.

The word bubble and ranking task worked well for the adult group. Several of the projective drawings done by the children included bubbles (see figure 3) so it was felt that the bubble drawings would also work well with them. Among other things the children were asked to rank (see section 4.3.3, number 8) pedestrian facilities and the IPD. They were given small pieces of paper with the name of each facility written on it, and placed them in order of preference. However, the triadic elicitation techniques used at this stage did not produce any new or potentially useful information. The projective drawings worked well with children and two drawings were found to be sufficient.

Finally, the sequence of the interview schedule proved acceptable although one change was thought advisable. As adults appeared to have some difficulty differentiating between fixed IPDs and existing pedestrian crossing facilities it was decided to discuss the portable device before the fixed device. It was hoped that this would familiarise subjects with the concept and so aid differentiation of the ideas.

To summarise, the main implications of the pilot study for the main study were as follows:

- Non-directive, focused and critical incident interview techniques were found to produce useful information in the adult and the child groups. However, it was felt that the same quality and quantity of data could be obtained with fewer questions and less lengthy discussions.
- Both adults and children were able to envisage fixed and portable IPDs.
- Evidence suggested that the word bubble and ranking task would be appropriate and useful for adults and children.
- Projective drawings were an useful aid to investigate childrens' attitudes and perceptions.

4.4 SELECTION AND SIZE OF SAMPLES FOR THE MAIN STUDY

For the main study it was decided to work with a small sample of males and females from each of five population groups, each representing a possible market for the IPD having distinct characteristics. A target sample size of 17 was chosen for each group.

The details are set out in sections 4.4.1 - 4.4.5 below, but in summary nearly all subjects were from one area (Enfield, Middlesex) and all were paid volunteers. Table 4 shows the breakdown by sex; there are considerably more females than males.

Table 4. *Interview Study: Males, Females and Total Number of Subjects in Each Group.*

	Number of Subjects		
Group	Males	Females	Total
Adults aged 18-60	7	8	**15**
Pedestrians aged 65 and over	6	12	**18**
Visually restricted	6	14	**20**
Parents of children aged 5-9	2	10	**12**
Children aged 10-14	10	9	**19**
Totals	31	53	**84**

There were two interview groups for each of the five population groups, except for the children where there were three interview groups. Table 5 shows the interview date, time and number of subjects in each interview group.

Table 5. *Interview Date, Time and Number of Subjects in Each Interview Group.*

Group	Date	Time	n
Adults aged 18-60	Thur 29.3.90	2.00pm-3.30pm	5
	Thur 29.3.90	7.30pm-9.00pm	10
Aged 65+	Tues 13.3.90	1.00pm-2.30pm	9
	Weds 28.3.90	10.30am-12.00pm	9
Visually restricted	Weds 14.3.90	2.15pm-3.45pm	10
	Mon 26.3.90	7.30pm-9.00pm	10
Parents	Weds 21.3.90	2.00pm-3.30pm	5
	Thur 15.3.90	7.30pm-9.00pm	7
Children aged 10-11	Tues 27.3.90	1.00pm-2.30pm	6
11-12	Tues 20.3.90	9.00am-10.15am	6
13-14	Tues 20.3.90	10.20am-11.35am	7

4.4.1 Adults Aged 18-60

This group account for 57.5% of the UK population (June 1994 figures), and represent a large market for IPDs. Subjects were recruited by advertising in local (Enfield, Middlesex) free papers (see appendix 7). Both interviews were run at the Enfield site of Middlesex University.

4.4.2 Pedestrians Aged 65 and Over

Subjects were recruited from two centres for the elderly in consultation with care professionals. It was convenient to recruit subjects from centres for the elderly. However, this means that the sample may not be representative of the 65+ population, for example they are possibly more sociable. A basic three stage mobility scale was adopted:

1 Only just able to leave the house.

2 Able to make short local journeys and use public transport.

3 Normal unrestricted adult pedestrian mobility.

This helped ensure that the full range of elderly pedestrian mobility was represented.

The first centre, The Rose Taylor Centre, was a local (Enfield, Middlesex) day care centre where members were for the most part brought in by disabled bus. The proportion who were mobility-handicapped was greater than that of the elderly population as a whole, and none had unrestricted mobility (category 3 above). Subjects were approached by the Officer in Charge and asked to participate in the interview. None refused.

The second centre was an Age Concern Social Centre in Ware, Hertfordshire, whose members tended to be physically more active. For example, they travelled to the Age Concern Centre by themselves, whereas the Enfield group had transport provided. Subjects were approached by the centre organiser and asked to participate in the interview. A few refused as the time was inconvenient. Subjects were selected by the centre organiser to include category 1 and 2 of mobility.

4.4.3 Visually Restricted

Subjects came from the visually restricted (VR) community in Enfield. Local rehabilitation officers selected participants who were over 18, with some degree of outdoor mobility and no other serious handicaps (e.g. deafness). Also, there were at least three participants who were adventitious or congenitally VR; blind or partially sighted; with or without guide dogs and working or non-working.

For the sake of convenience VR pedestrians were selected for one interview session from an occupational therapy group. This was organised by the rehabilitation officers, and held at the Park Avenue Day Care Centre. Extra subjects who met the requirements were asked to attend to make up the numbers. For the other session each VR pedestrian was collected from his or her home and brought to Middlesex University for an evening interview. Interviewees in the evening group tended to be those who were working and hence may be considered more independent than those who attended the Day Centre session.

4.4.4 Parents of Children Aged 5-9

At this age children are usually learning how to cope with the road environment. They trust adult's advice and they accept new concepts presented to them. For the most part, their parents decide what freedom of movement they will have, what aids they will benefit from and which ones they will be allowed to have.

Parents were contacted through a local (Enfield, Middlesex) primary school. One hundred and seventy letters were sent out to a potential three hundred and forty parents asking for paid volunteers. Unfortunately, the response was very poor and despite efforts to schedule interviews at convenient times it was not possible to obtain the number of subjects required. Further attempts were made to get parent with children in this category from other local schools, however, at short notice, these were unsuccessful.

The parents that were interviewed were volunteers, and it is assumed that they were motivated by either the financial reward, a special interest in their child's road safety, or both.

4.5.5 Children Aged 10-14

The children were divided into three groups instead of two because the size of the group should generally be reduced for child interviews (children's conversations are not as disciplined as adults, and this makes large group discussions difficult to understand). The group interview situation is in any case somewhat artificial for children for several reasons. For example, children are not usually asked to discuss 'topics' with adults that they know, let alone adults who are strangers to them; also, children are taught that it is rude to ignore an adult who is 'involved' in conversation with them. Children often direct comments to any adults that are present because of a need to seek approval or to win special attention. This does not mean that group interviews are not suitable for children, only that greater care needs to be taken.

Ten to fourteen year olds are beginning to develop independent attitudes, opinions and behaviours from those of their parents, teachers and other adults. These are often more 'modern' in outlook as the new generation rejects old values and accepts new ideas and technology. This group could then be a barometer of the next generation's attitude towards IPDs.

The children were selected from the same local primary school used above, and also from a secondary school in the same area. The whole age range was covered. Parents of the primary school children were informed and given the opportunity to refuse permission;

none did.

4.5 EQUIPMENT AND MATERIALS

The interviews were video recorded, and the equipment used is detailed in section 8.3.2. Some of the materials required have been described in the previous sections, (4.1, 4.2). However, for convenience all of them are listed below with the appropriate appendix number.

		Appendix
-	Form for recording road use	5
-	A bubble drawing	1
-	Blank paper and felt tip pens for projective drawings	--
-	Line drawing, artist's impression of a fixed stand alone IPD	8
-	Written description of a portable, active, non-selective IPD (adults)	9
-	Written description of a portable, active, non-selective IPD (children)	10
-	Written description of a fixed, stand-alone, passive, selective IPD (adults)	11
-	Written description of a fixed, stand-alone, passive selective IPD (children)	12
-	Model of a portable IPD (pictured in)	13
-	Rank order pedestrian facilities form	2
-	5cm x 8cm pieces of paper with name of a pedestrian facility written on each one	
-	Follow-up questionnaire.	3

4.6 MAIN STUDY.

The format of the interviews for the main study did not differ greatly from that of the pilot interviews. The full adult and child interview schedules are in Appendices 14 and 15 respectively.

There were two minor additions:

1 For children, a focussed question about the fixed IPD.

2 For adults, further focussed questions about how much users would be prepared to

pay for a portable IPD, and how reliable they would expect it to be. Also, a follow-up questionnaire was included. (See section 4.2.2). In addition, some minor alterations to the phraseology of questions were necessary in order to cater for the special requirements of each group, as outlined later in section 4.6.1.

All subjects, except the children were paid a fee of £5. Each adult was paid at the end of the interview. For each child interviewed £5 was donated to his or her school's fund.

4.6.1 Changes to the Basic Format of the Interviews.

Minor changes to the format of interviews were necessary in three groups. Firstly, questions asked to the visually restricted interview groups were phrased to apply to visually restricted pedestrians. To be discreet, visually restricted interviewees were not asked the following questions taken from the basic format shown in appendix 14:

5c In general whose fault do you think accidents to VRP's are?

5d What sort of VRP do you think become pedestrian casualties?

7a iv). Do you think VRP would buy it? (a portable IPD)

Neither was the word bubble exercise administered to this group nor was an artist's impression of the fixed IPD given. Question 7c (for whom you would buy a portable IPD?), was confined to 'I)Yourself', and 'V) Anyone else?' Lastly, for convenience, the rating task was moved to the end of the session just before paying the interviewees.

Questions asked of the parent groups also had the words re-phrased so that they referred to their children and not to themselves. This meant that some questions were not appropriate and had to be replaced or left out. The non-directive questions were replaced with the following questions:

4a As pedestrians, do you think your children face any particular problems?

4b Do you think your children have any particular problems crossing the road?

Questions7 iv), v) and vi) concerning whether the parent would buy a portable IPD, how much they would pay for it and how accurate it would need to be, were replaced by the question:

Would you trust it (a portable IPD) for your child? and

Would you tell your child to use it?

Question 5d 'What sort of people do you think become pedestrian casualties?' was not included.

In addition to this, the word bubble exercise was completed as if the child were talking to the parent. Only the first part of the rating task was completed (most safe for your child -least safe for your child), and parents were asked to complete the follow-up questionnaire from the point of view of their child.

Finally, the children in the 13-14 age group were not asked to do the first projective drawing. This was done so as not to offend subjects who perceived themselves as 'adults' for whom it would be inappropriate to draw pictures of imaginary devices.

In conclusion, it was felt that the group interview method was most appropriate for this work. The IPD is a new concept, and group interviews are ideal for uncovering the range of opinions on new products. The main disadvantage of the group interview is that it can prevent people from expressing minority opinions. However, this study also included a follow-up questionnaire, that would allow people the opportunity to express opinions that they may not have felt able to give in the interview. The results of the main study are given in the following chapter, together with a discussion and the conclusions of the work.

CHAPTER 5. RESULTS,DISCUSSION AND CONCLUSIONS OF THE INTERVIEW STUDY

CHAPTER 5. RESULTS, DISCUSSION AND CONCLUSIONS OF THE INTERVIEW STUDY.

5.0 INTRODUCTION

In this chapter the results of the interviews on the social acceptance of IPDs are given. Results for the whole sample, and where appropriate for each of the five main sub-samples are outlined. The raw interview data was analysed by organising and summarising the opinions expressed in defined categories e.g. 'liked pedestrian facilities'. Other data were organised into categories which emerged from the interviews themselves. In reporting the results, comments are compared and contrasted and quotations are selectively used to illustrate the conclusions.

In addition to the purely qualitative analysis of the interview data some simple counts of comments were made. Also, the ranking task results and the follow-up questionnaire were subjected to statistical analysis.

The results are discussed in relation to their repercussions for IPD design and use. The chapter begins by outlining the interviewees' exposure to the road environment. Attitudes and perceptions about walking are then reported. Following this, attitudes towards pedestrian facilities are outlined and compared to attitudes towards IPDs. The results of consumer groups for whom a portable IPD might be suitable, and what an acceptable price for it might be, are reported. Attitudes towards the fixed IPD are also discussed. Finally, conclusions are drawn about the likely social acceptance of IPDs.

5.1 INTERVIEWEES' EXPOSURE AS PEDESTRIANS AND DRIVERS

This section outlines interviewees' exposure to the road environment. Table 6 shows the perception subjects have of traffic levels in their neighbourhoods and those who said they had to cross a heavily trafficked main road when going out. As shown, the majority of the interviewees (73%) thought that their local traffic was heavy, and 88% reported nearly always having to cross a heavily trafficked main road when leaving their home. The 15%

increase is presumably due to those pedestrians who did not perceive themselves as living in a heavily trafficked area travelling further from home to heavily trafficked areas. These results reflect the urban environment of North London where most participants lived. Only one of the elderly groups was not from North London.

Table 6. *The Number of Subjects in Each Sub-Sample that Reported Local Traffic as Light, Medium and Heavy, and Usually Having to Cross a Heavily Trafficked Road When Out.*

	Number of Subjects					
Level of Traffic	Adults	Elderly	Visually Restrctd	Parent	Child	Total
Light	2	2	0	0	3	6
Medium	3	7	0	0	7	17
Heavy	10	10	20	12	9	61
Totals	15	18	20	12	19	84
X Heavy Traffic Rd.	13	16	18	12	15	74

These results show that most interviewees' experience of the road environment included roads where the volume of traffic would probably mean long delays when waiting to cross with a portable IPD. Samples from less heavily trafficked areas may produce different results.

Table 7 gives a broad indication of the interviewees' involvement in walking. No results are shown for the parents' group as it was their childrens' walking habits that were required. Only 3 of the children of the 12 parent interviewees were allowed to cross local roads alone and only one walked to school alone. Three of the visually restricted group used a guide dog to aid mobility. The table shows that the samples included people with different levels of mobility.

Table 7. *The Number of Interviewees in Each Sample that Reported Walking as Little as Possible, Less Than One Mile and More Than One Mile Per Day.*

	Number of Subjects					
Distance Walked	Adults	Elderly	Vis.Res.	Parents	Child	Total
As little as pos.	1	5	3	n/a	1	10
Less than 1 mile	5	4	6	n/a	8	23
More than 1 mile	9	9	11	n/a	10	39
	15	18	20	0	19	72

There were only 10 car drivers in the sample (nine of the adult and 1 of the elderly sample), so the results probably do not reflect the opinions of car driving pedestrians.

5.2 ATTITUDES TOWARDS BEING A PEDESTRIAN

This section outlines interviewees' opinions about walking, difficult situations and accidents; and then discusses the repercussions of these for the IPD.

Many of the people in the adult groups talked about walking as a morally better way of travelling than using vehicles. However, for the most part people took a more pragmatic view. In particular, the adults' responses indicated their belief in a hierarchy of road users in the road environment: motorists at the top and pedestrians at the bottom. Also, parents were aware that their children came at the very bottom of this hierarchy.

The children's attitudes appeared to change gradually with increasing age from apprehension towards the potentially dangerous road environment, through to convenience orientation, in which behaviour is characterised by whatever is most convenient. The change involved exploring and later challenging the road environment in order to master and control it. The experience of independent mobility appeared to be responsible for this change in attitude and behaviour, although a change in attitude with maturity may encourage independent mobility. Also, evidence suggested that parents may re-inforce this control theme with their children by stressing control issues e.g. by talking about enforcing road regulations.

The control theme emerged most clearly in the visually restricted group. Perceived control of the road environment was strongly linked with the confidence to travel independently. Some felt that they 'shouldn't cross alone' except under exceptional circumstances and that 'if you haven't got the confidence you should wait for someone to help'. Confidence and control were not related to degree of visual impairment, but were more a state of mind. Confident road users were in control of their lives, they could be self-directed. The elderly showed less confidence; walking and travel appeared to be troublesome. Adults felt confident and in control; they perceived themselves as on top of the pedestrian hierarchy.

Visually restricted pedestrians complained about obstacles in their path and environmental noise, so that one 'can't tell where the traffic is coming from'. Most groups complained about heavy traffic and aggressive driving. Adults talked about a wide range of these problems whereas the elderly tended to have a more problem-centred approach. Their confidence was waning along with their health, and that meant sticking to regular trips. These often involved a specific, recurring safety problem.

All groups tended to blame drivers for pedestrian accidents. Although some people, especially the elderly, were aware that they could be at fault through, for example, lack of concentration and an inability to gauge distances. Parents were aware that their children often acted without thinking, but children made surprisingly few comments about things that they found difficult. The oldest children appeared to deny problems existed with a show of bravado. The following extract from the oldest child group illustrates this.

S6 People of our age don't look
S4 Small kids don't have to go to school alone
S2 At our age we're not bothered
S1 We've got other things on our mind
S6 We don't think it's going to happen I suppose

Pedestrians' own solutions to problem situations included the full range of options. Elderly and visually restricted groups suggested more and better facilities. Adults, parents and the oldest two groups of children suggested some type of enforcement, mostly against drivers. These solutions made by these groups suggest that the able bodied groups seek control over the existing environment whilst the physically impaired seek extra assistance to help them cope.

The visually restricted thought that it would 'help to be more independent'. The adult, elderly and parent groups suggested better planning of the pedestrian environment; often because they wanted to prevent crossing away from a designated crossing. Interestingly, all groups suggested some type of education, for example, a TV campaign using gory effects to perturb people and newspaper reports on accident spots. The emphasis that interviewees gave to education in road safety suggests that people believe themselves and others to be open and ready to respond to information and advice. Hence, people may be willing to receive and evaluate information about the IPD. Many pedestrians stated that the media has a powerful influence which should be used to change attitudes.

The main concerns that emerged surrounding attitude towards being a pedestrian, that is: road user hierarchy, perceived control of one's environment, confident road use, personal responsibility and independent mobility are all relevant to IPD design and use. Therefore, the IPD could play an important role in addressing pedestrians' concerns. For example, the IPD could be perceived as an aid to help control the environment. This would increase confidence and assist visually restricted pedestrians in achieving greater independence. Also, the portable IPD would give individual assistance, and hence would meet the needs of the elderly group. By meeting the stated needs of pedestrians the IPD would be more socially acceptable.

5.3 ATTITUDES TOWARDS PEDESTRIAN FACILITIES

The results on attitudes towards pedestrian facilities are taken from interviewees' comments and a ranking task which illustrated general views on both 'perceived safety' and 'like of use' towards nine pedestrian aids (including fixed and portable IPDs). Appendix 16 shows for both scales, the mean rank, range of and the rank of the mean rank for each of the groups. All groups completed the perceived safety ranking (three were spoilt, one from the child group and two from the elderly group (N = 81)). The adult, elderly and child groups completed rankings on the scale like using most/least (four were spoilt, one from the child group and three from the elderly group (N = 48)). A short summary of interviewees' comments and the rankings for each facility are in appendix 17. The IPDs are discussed in the next section.

Spearman's Rho tests were carried out to see if there were any correlations between the sub-samples'mean rankings on the perceived safety and like of use of the nine pedestrian facilities. The results in tables 8 and 9 show the co-efficients for each of the pairings on perceived safety and like of use, respectively. A 5% significance level was set. For perceived safety the only paring that had a significant correlation was the adult and parent group with a correlation of $rs = 0.900$, $p < 0.01$.

Table 8. *Spearman's Rho Correlation Co-efficients for Sub-Samples' Mean Rankings of the Perceived Safety of Nine Pedestrian Facilities.*

	Correlation Co-efficients			
	Adult	Elderly	Vis.Res.	Parent
Elderly	0.550			
Vis.Res.	0.400	0.467		
Parent	0.900	0.667	0.600	
Children	0.433	-0.217	0.017	0.150.

These two sub-samples are similar in many respects. However, parents were asked to rank facilities in relation to their children's need, therefore a difference in rankings might have been expected. Parents may not have ranked the facilities with their children in mind, or they may have believed that the safest facilities were the same for themselves and their children. Parents' mean rankings were similar to those of the whole sample, indicating that parents have a representative view of the safety of pedestrian facilities.

For like of use (see table 9) the only pairing that had a significant correlation was the adult and child group, with a correlation of $r_s = 0.917$, $p < 0.01$. This may be due to similarities in levels of stamina, and attitudes towards convenience. For example, adults and children probably liked footbridges (rated 3 and 1 respectively) much more than elderly pedestrians (rated 9) because they are more able bodied.

Table 9. *Spearman's Rho Correlation Co-efficients for the Adult, Elderly and Child Sub-Samples' Mean Rankings on the Like of Use of Nine Pedestrian Facilities.*

	Correlation Co-efficients	
	Adult	Elderly
Elderly	0.687	
Children	0.917	0.672

Within each group there was a wide range of rankings for each facility (see appendix 16). This may indicate that personal experience and/or exposure to different road environments is more salient in deciding individual's opinions about pedestrian facilities than membership of a particular group. If so, then it will be important to assess how individual's experiences might affect perceptions of the IPD.

All groups spontaneously complained about pedestrian crossing facilities during the non-directive interview. Indeed one of the children suggested that no facilities were very good 'they should invent something else'! In summary, many pedestrians are not satisfied with the current level of assistance. The IPD may be the additional help they require.

5.4 GENERAL PERCEPTIONS OF THE PORTABLE IPD

Results reported in this section on the general perception of the portable IPD came from several sources: the projective drawings, the bubble drawings, the interview and the follow-up questionnaire. The following concentrates on perceptions of the portable IPD, although some of the conclusions are equally valid for the fixed IPD. The next sub-section summarises the design features suggested during the interviews.

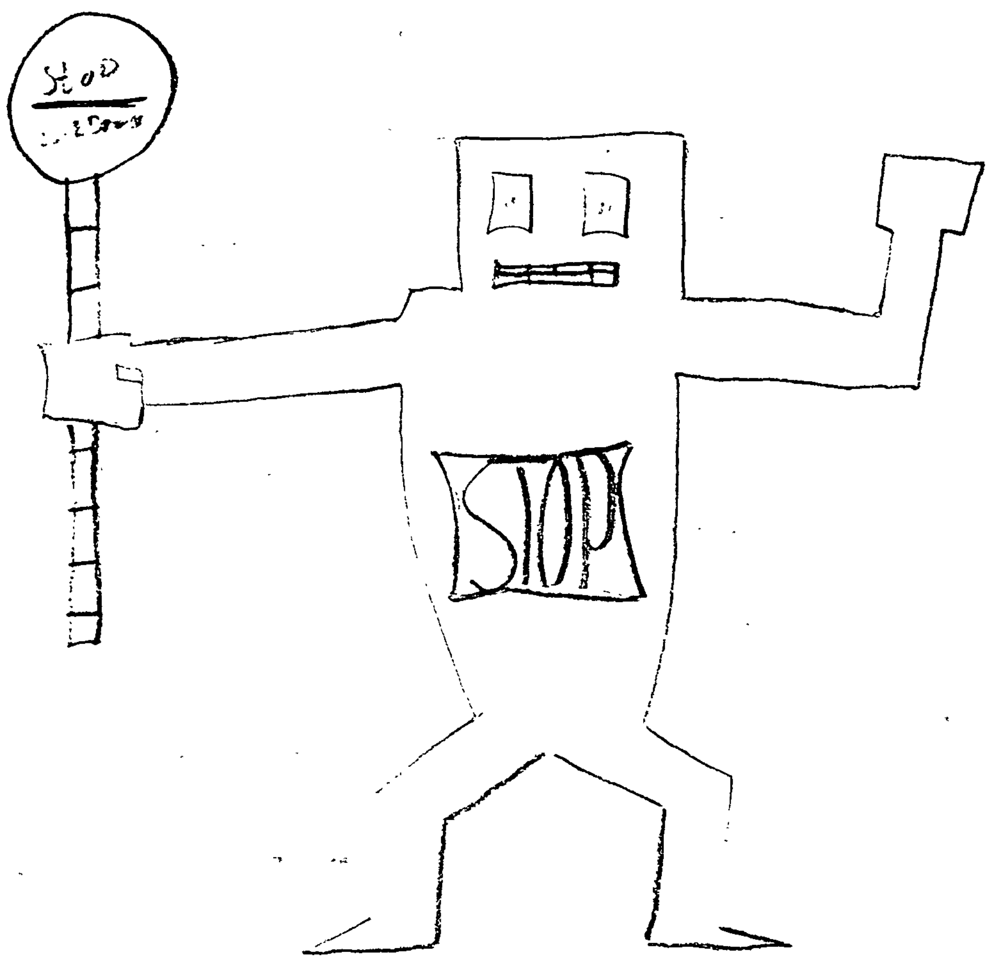
Initial comments about the portable IPD made in all groups, except the youngest of the children, showed some scepticism. Positive comments were limited, examples are, 'it would be useful for blindspots', or for country people trying to adjust to London traffic. The visually restricted group were most positive, with most agreeing it would be an excellent aid for them.

The first set of projective drawings on 'an aid you would like to help you cross the road', was done by the two youngest of the three groups of children. A description of these is given in appendix 18 and some examples together with brief descriptions can be seen in figures 4-6. The 'robot lollipop lady' depicted in figure 4 is closest to the functions of the IPD. All other aids drawn can be described as falling into three main categories: those that stop vehicles, those that avoid vehicles, and help by other people. In short, the portable and fixed IPDs appeared to be completely novel ideas to all of these interviewees.

The second set of projective drawings in which the same children were asked to depict a story of a child out one day with a portable IPD, and the older children were asked to depict and describe a portable IPD are outlined in appendix 19. Figures 7-12 show some of the drawings and descriptions. Some descriptions of a portable IPD contradicted what the interviewees had been told about the device, indicating that they were still unclear about its operations. Most stories showed users crossings the road safely, but showed problems e.g. powering the device and inclusion of a failsafe mechanism.

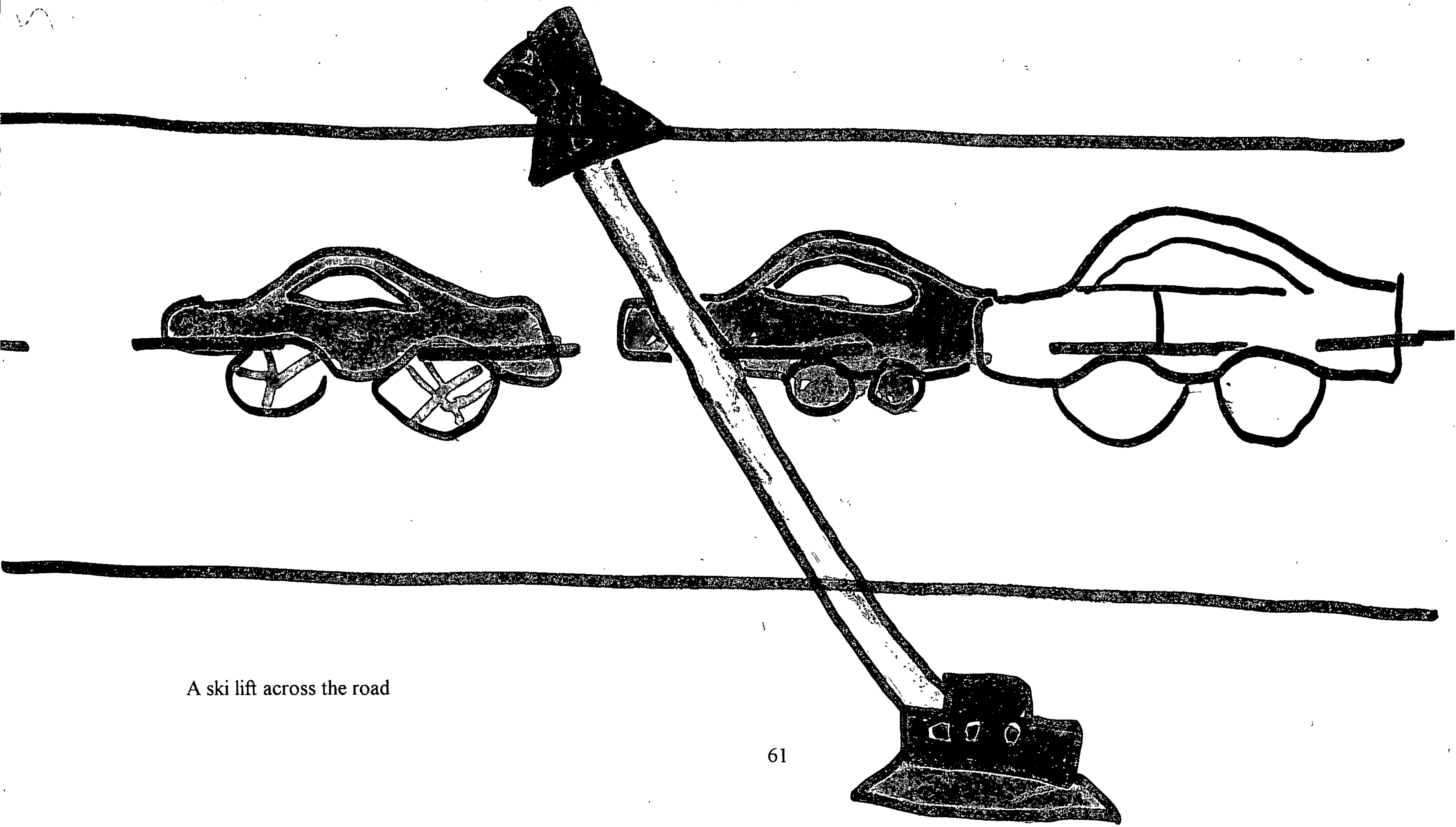
Figure 13 below illustrates some of the responses made about the portable IPD in the bubble drawings. Appendix 20 lists the negative, neutral and positive statements made for the adult, elderly, parent and child sub-samples that completed this task. The bubble drawing results showed that a number of people, especially in the adult sample, had worries concerning IPD use. These are outlined in the following discussion.

Figure 4. A Projective Drawing and Description of 'Something toHelp You Cross the Road' by Richard, Aged 9.



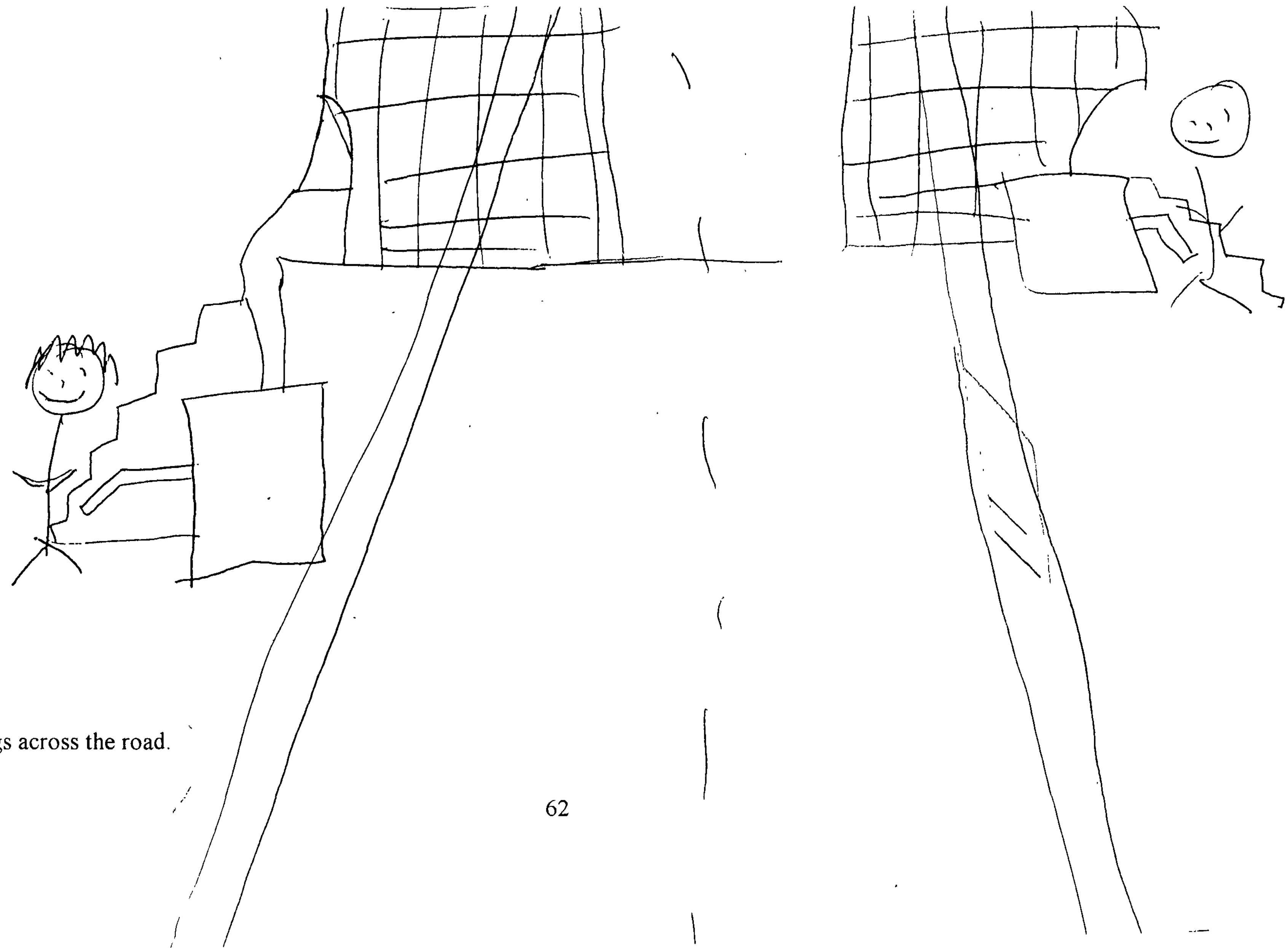
A robot lollipop lady.

Figure 5. A Projective Drawing and Description of 'Something to Help You Cross the Road' by Yvonne , Aged 10.



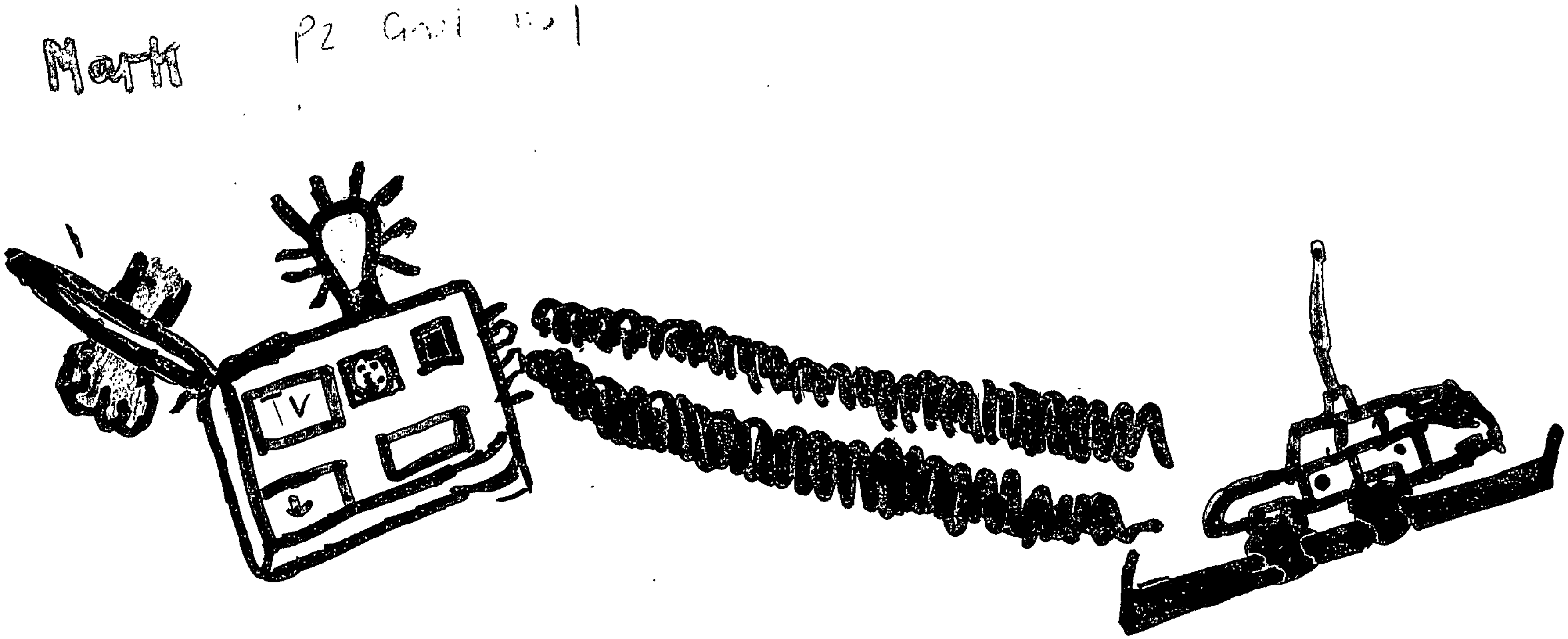
A ski lift across the road

Figure 6. A Projective Drawing and Description of 'Something to Help You Cross the Road' by Lindsey, Aged 12.



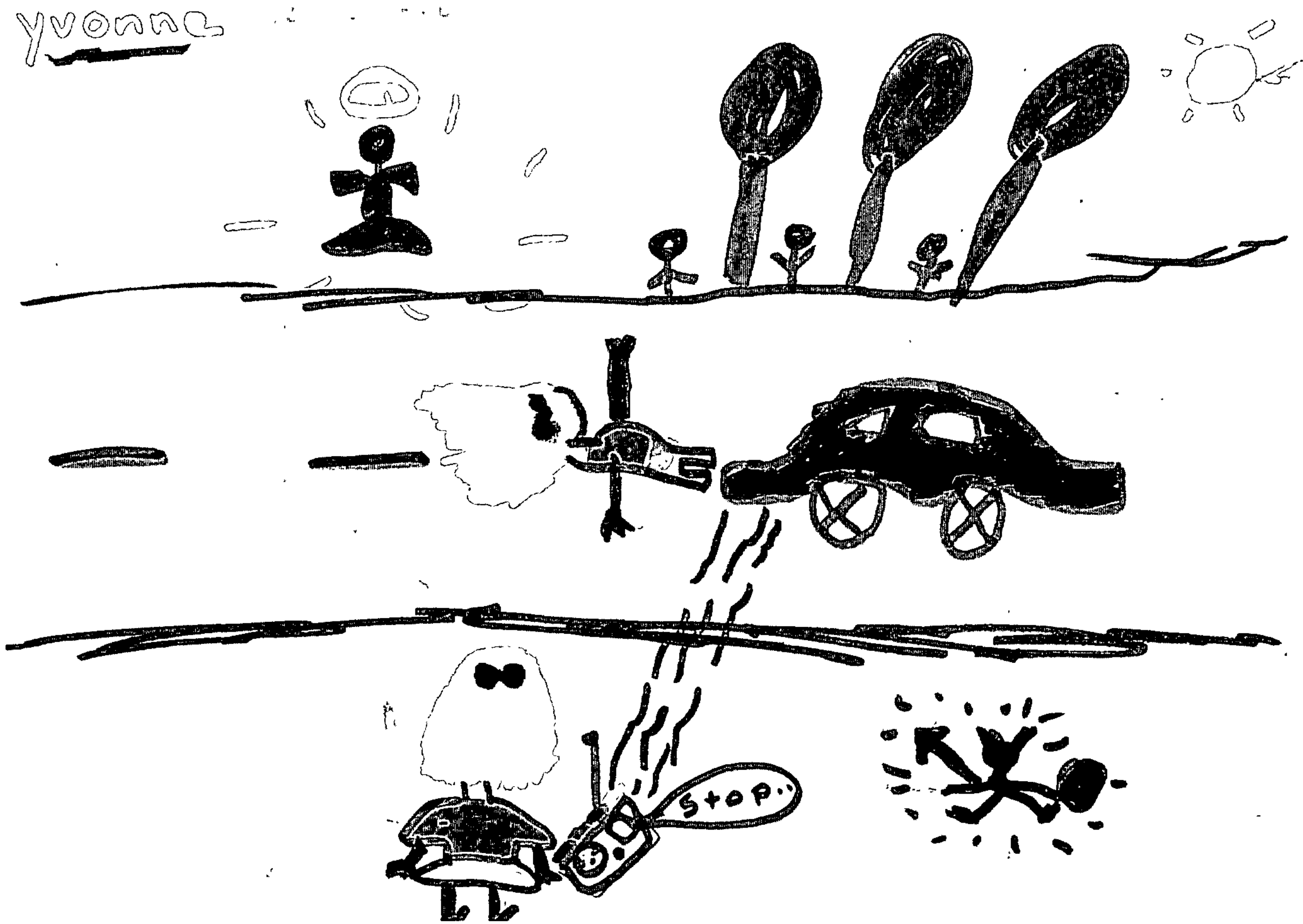
A cage swings across the road.

Figure 7. A Projective Drawing and Description of 'A Child Out One Day With a Portable IPD' by Mark, Aged 11.



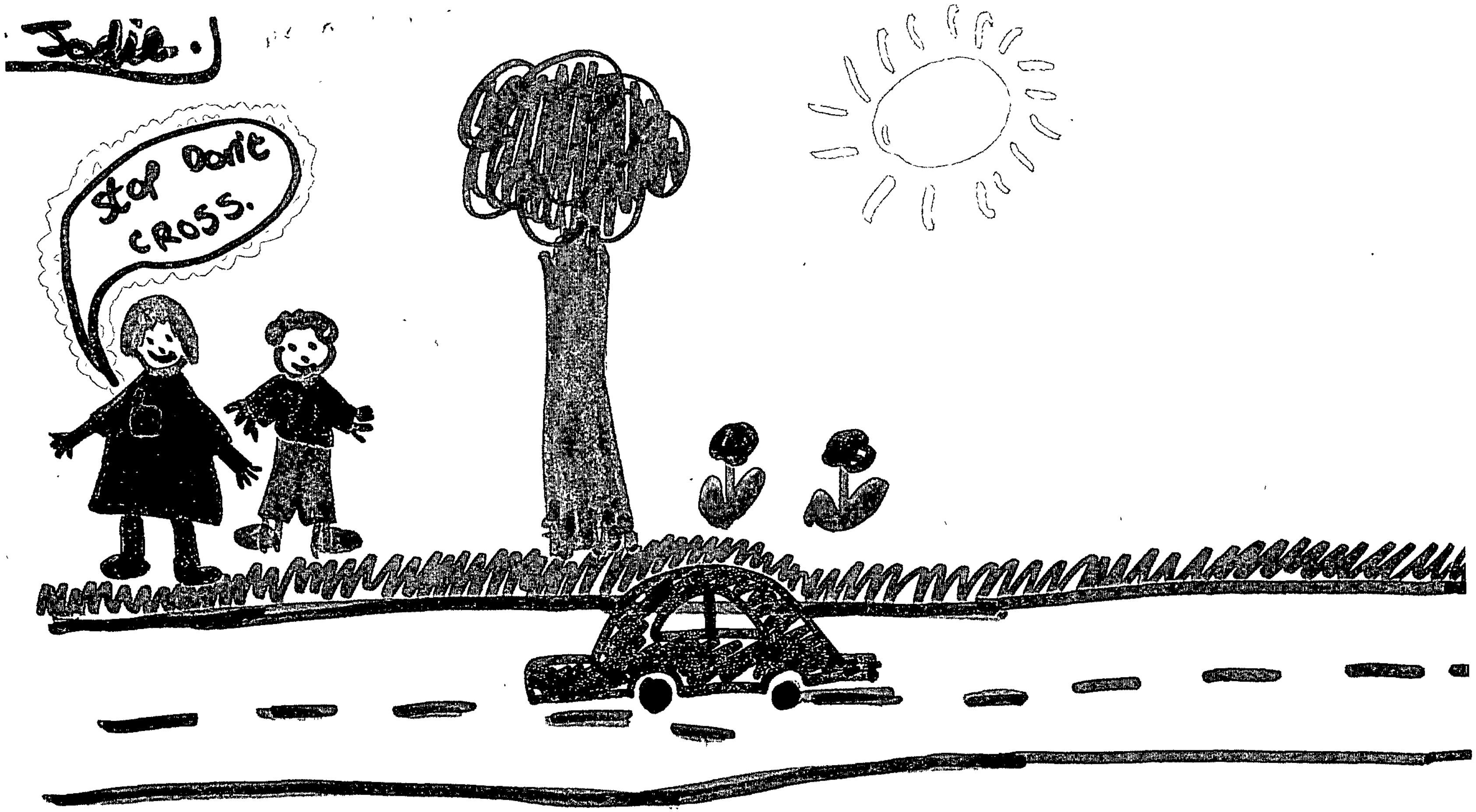
Battery or solar powered with a light to show if it was not working. The child drops it, it breaks but still works. At home Dad fixes it.

Figure 8. A Projective Drawing and Description of 'A Child Out One Day With a Portable IPD' by Yvonne, Aged 10.



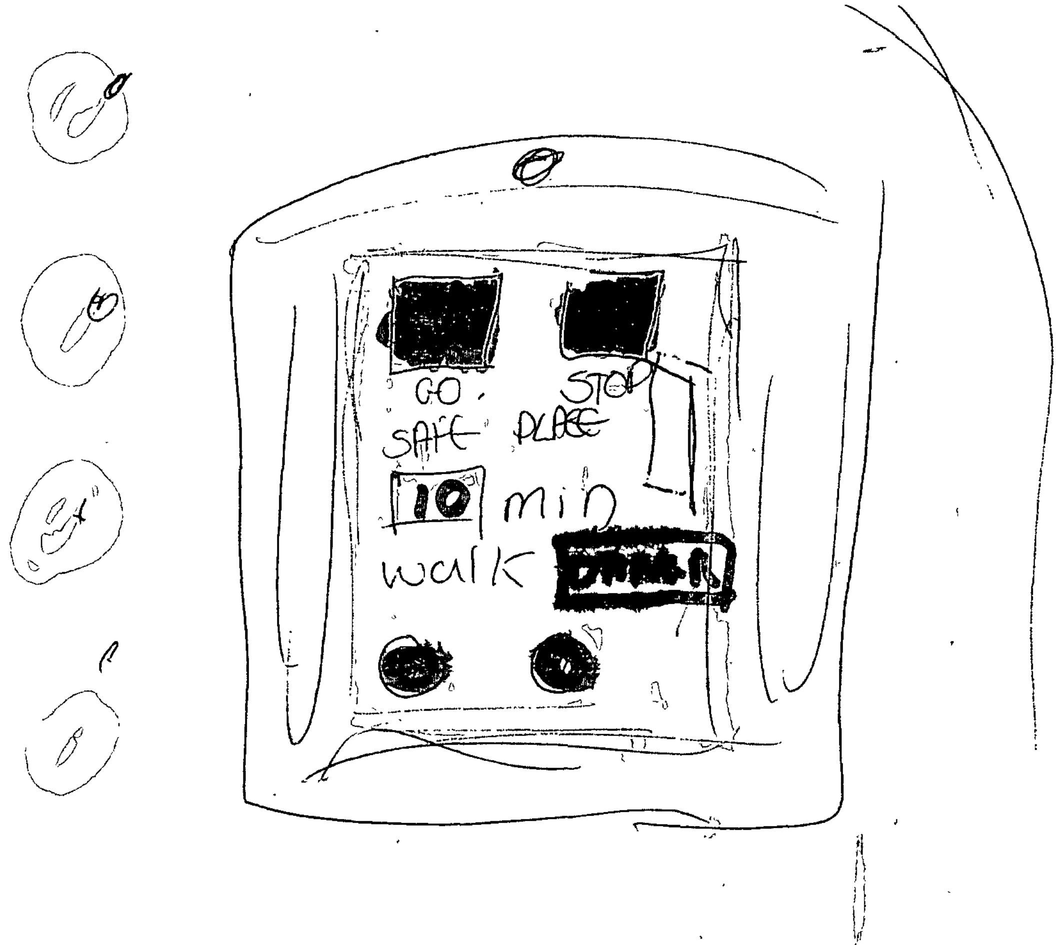
Press button for use and waves come out. Two girls: an angel protects and a devil wants to get the girls run over. The devil tells the girl with the IPD not to use it, but she does. The girl without the device gets run over.

Figure 9. A Projective Drawing and Description of 'A Child Out One Day With a Portable IPD' by Jodie, Aged 11.



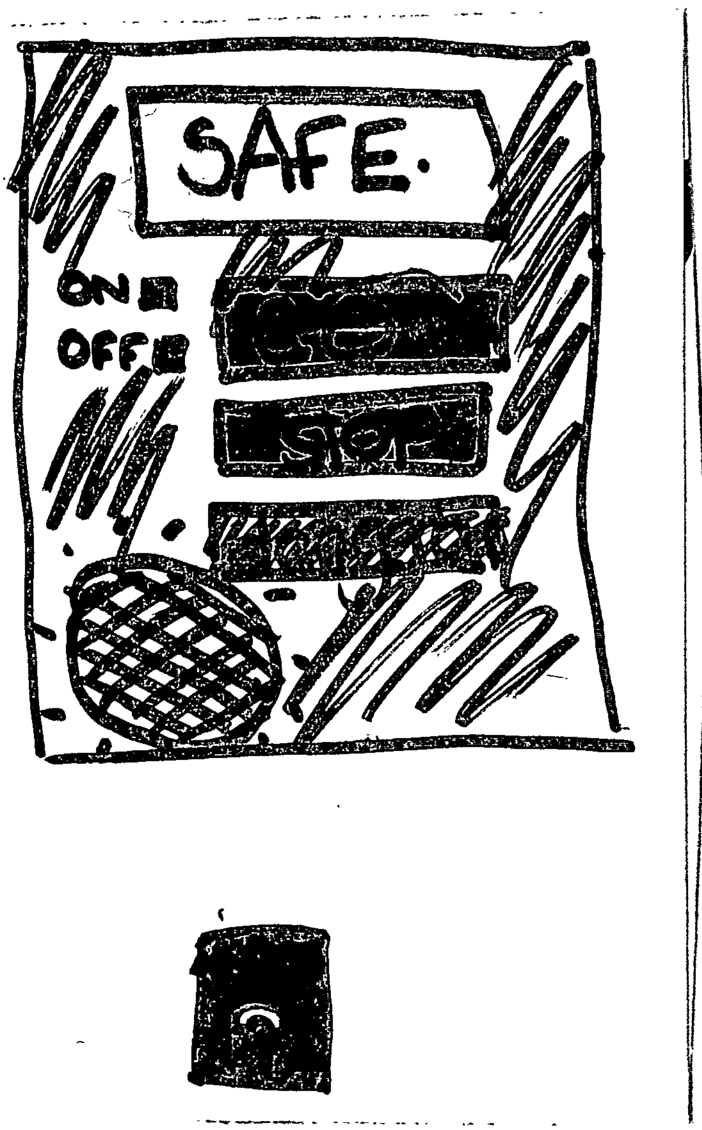
Solar powered with a bleep if it's not going to work. A girl with her new device talks and laughs with a boy. She is just about to walk into the road and the device tells her not to.

Figure 10. A Projective Drawing and Description of 'A Child Out One Day With a Portable IPD' by Laura, Aged 11.



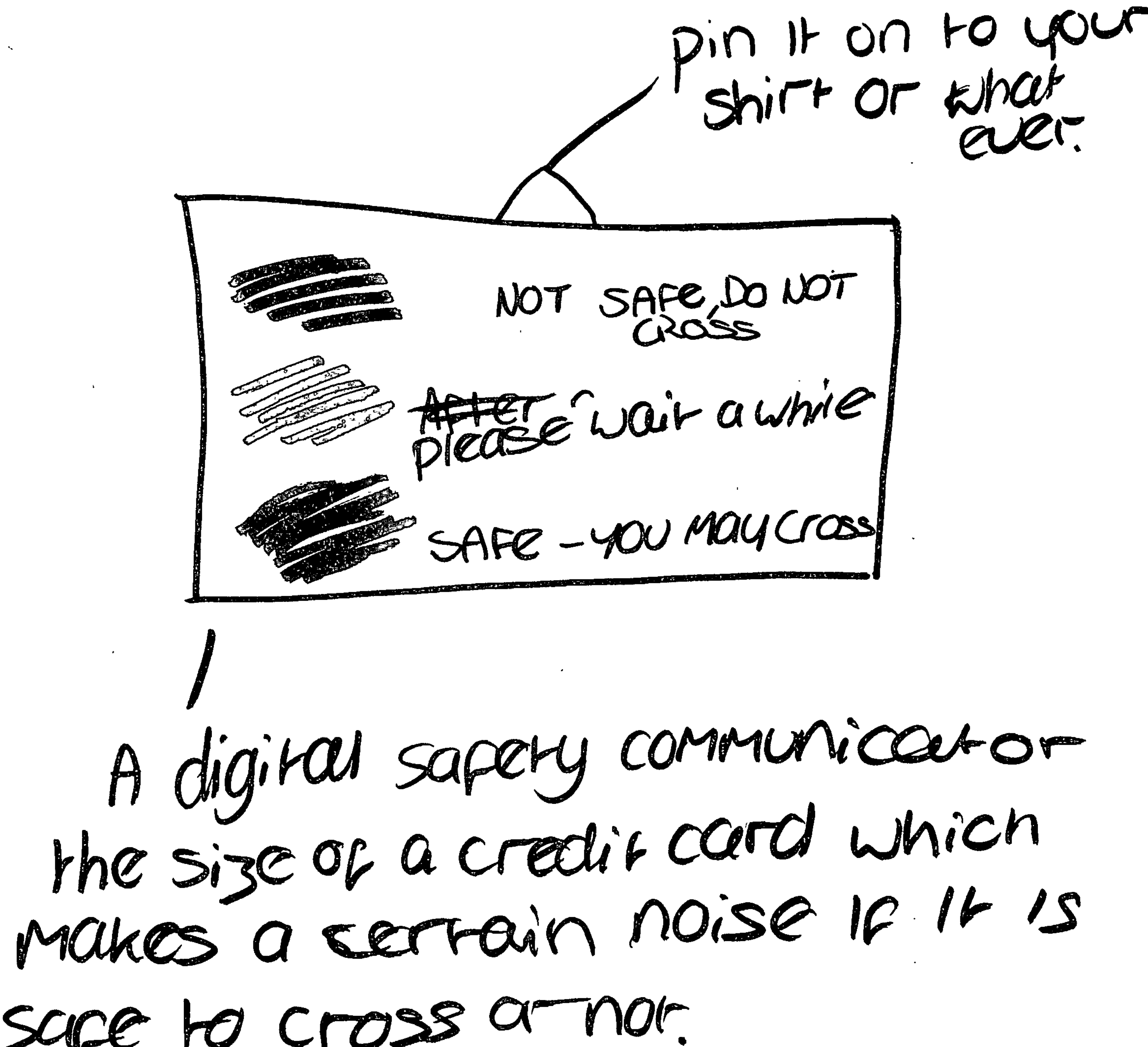
Brightly coloured so you remember it. Two boy: one used it and was a 'good boy', the other did not and was a 'bad boy' and he got run over.

Figure 11. A Projective Drawing and Description of 'A Child Out One Day With a Portable IPD' by Elena, Aged 12.



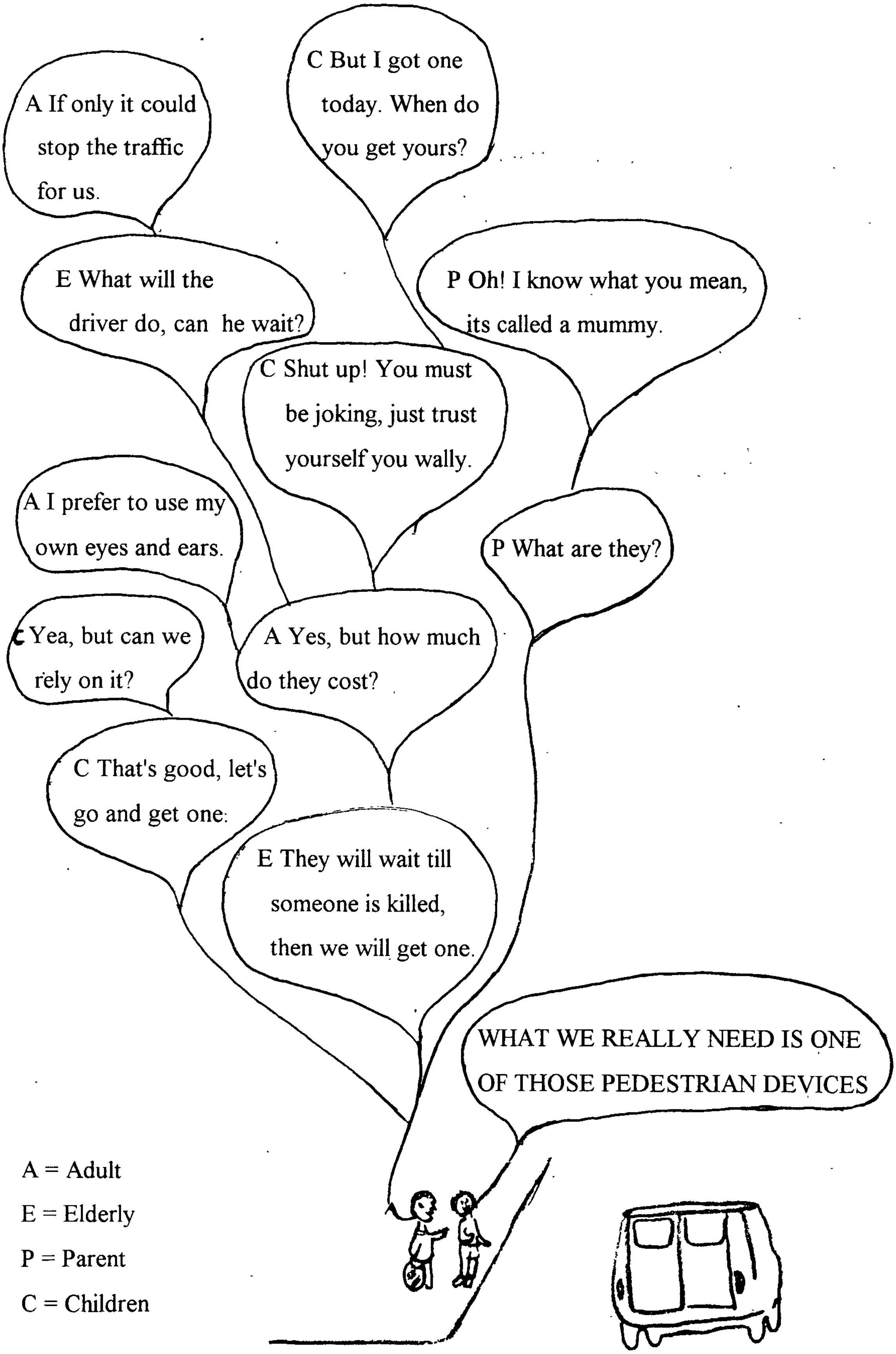
The device told a girl of 7 to stop, she ignored it and ran to a friend.

Figure 12. An Illustration and Description of A Portable IPD by Jo, Aged 14.



Digital, credit card size, with a visual and auditory signal.

Figure 13. Composite of Some of the Bubble Drawing Responses.



Many of the adult sample felt that the level of traffic on our road network would make using the portable IPD very difficult. This may mean that adults envisaged using the portable IPD on densely trafficked roads rather than on side streets, which is an assumption that some of the other less confident samples may not have made. Adults said that a portable IPD would have to be 'too safe (and) you wouldn't use it in the end'. Thus indicating that adults recognise that they are prepared to take risks for expediency. Confronting people with their attitude and with evidence of their risk taking behaviour (in the form of the advice given by the portable IPD), may help them to re-assess their level of risk acceptance.

Some people argued that an IPD should not be required in our society, inferring that government should make the road environment less vehicle oriented. Other solutions to the pedestrian accident problem like 'devices in cars to automatically brake if a pedestrian steps out', were suggested. Parents felt that they should not have to buy their childrens' safety.

Some of the adult sample said that IPDs 'could take the onus from drivers and pedestrians to be totally responsible at all times for the safety of all our roads'. This suggests that when crossing the road people have a kind of social barometer in their head that subconsciously assesses how much care and attention motorists are likely to be taking of them. They have an awareness that personal responsibility is mediated by the behaviour of others around one. The balance of responsibility for pedestrian safety may change with portable IPD use, but if it is shown to reduce pedestrian accidents then it may become a politically attractive alternative. That is, it may be accepted and encouraged by the government as a solution to the pedestrian accident problem. However, pedestrians who do not have or cannot afford a portable IPD may suffer the consequences.

There was a sense that the adult sample felt that they could cope with whatever they were faced with in the road environment, and a feeling of almost invulnerability to accidents. These ideas may be unrealistic, but perhaps they help bolster feelings of self control. If the portable IPD is seen as a substitute for human capabilities rather than an aid to crossing it may threaten feelings of personal freedom and self direction.

The response of the oldest children in the 10-14 year old sub-sample also seemed similar to the adults; they did not want to be told what to do by anyone or anything. It was as if the portable IPD was taking away their new found independence and autonomy. Educating young people that a portable IPD is a servant to the user, rather than an authority to be obeyed might help allay negative attitudes.

Parents were also concerned that their children would not learn how to cross the road safely if they used a portable IPD. This supports the idea that the portable IPD was seen as taking over responsibility for behaving safely. They worried that their children modelled adult's unsafe crossing behaviours. But, they did not consider that the portable IPD could be a good model to the child, as it would only advise crossing when it was safe.

Parents, adults and the older children argued that their own faculties were better than any technological invention and that they would sooner rely on their own judgement. One child summarised feelings with the comment 'we've done alright till now' crossing independently. A general mistrust of technology was illustrated in the bubble drawings and often explicitly stated. Interviewees only had limited information about the IPD; people may become more accepting when they have more information or when similar types of technological inventions become more commonplace.

The follow-up questionnaire, completed by the adult, elderly, visually restricted and parent groups included a question on what the lowest acceptable level of accuracy for a portable IPD should be. All interviewees, except two of the parent group returned their follow-up questionnaires and Appendix 21 shows the number in each sub-sample that reported various different lowest acceptable percentages of accuracy. 44% thought the portable IPD should be 100% accurate. Requiring this impossibly high level of accuracy may reflect the general mistrust of technology.

More problems were anticipated at the human end of the man-machine interface. Children said that they might misuse the device or not pay attention to it, and parents felt that their children might abuse it. For example, one parent said 'they might use it to see how close a car can get before it tells them not to go'. Alternatively, there were worries that children and the visually restricted might come to view the portable IPD as almost magical, and become over reliant on it. All of these possible misconceptions about IPD use would need to be refuted by means of education.

Some interviewees, in particular, the older children said they might feel self conscious using a portable IPD. For example, one child said 'people will say "that person's weird they've got a talking box" '. Self consciousness is a feature of adolescence because young adults have a tremendous need to conform with their peers. The novel nature of the IPD may cause self-consciousness and so initial acceptance might be difficult, but with more widespread use attitudes would probably change. Also, careful design could help reduce the conspicuousness of users.

Self confidence was relevant in two ways. Firstly, some interviewees, particularly in the 65+ group, thought that the portable IPD might increase their confidence in negotiating the road environment. Secondly, some interviewees felt that they would need to feel confident in using the device. The visually restricted group were clear about the need for training to learn how to use it correctly, and this would seem like an essential pre-requisite for this group. The elderly group were also worried about dividing their attention between the road environment and the IPD's advice, and it is possible that some elderly people might require training. However, training sessions would increase costs. If possible, it would be better to use simple designs that were easy to understand and thereby reduce the need for training.

5.4.1 Suggested Design Features for an IPD

Suggested design features of a portable give some indication of what users might expect. Concerning size of device it was thought that it might need to be quite large, but preferably it would be wrist watch or credit card size. There was also concern that one might forget to take the device out, and so attaching it to something one already uses or ensuring that it is eyecatching was suggested.

There was some concern about the level of noise that an IPD might produce, especially if several people were using one in the same vicinity. An earpiece could be used, or one suggestion for pedestrian convenience was a volume knob. Also, a mechanism that could automatically increase the level of volume if the user was in danger was suggested. Advice is probably better given aurally. However, there could also be a visual indicator, especially suitable for people with hearing difficulties; green for safe and red for unsafe.

The model portable IPD shown in the interview used words to tell the user whether or not to cross. Using words, volume needs to be loud enough to hear and perceive the meaning. By replacing the words with sufficiently different sounds for safe and unsafe, the volume could be decreased. The number of different types of advice or sounds emitted would depend on the functions of the device. For example, a portable active selective device (see section 1.1 for a description) would only require one signal. No signal would mean that there were no vehicles of threat to the user; a signal would mean it was unsafe to cross the road at that time.

The visually restricted group noted some features that would be required to enable them to use the portable IPD. The device would first need to locate the kerb for them, and then advise if they wandered from their path across the road. This would probably make its functions more complicated, and might confuse users who do not need those facilities. For this reason, it would probably be better to have a different model of IPD which incorporated these functions.

5.5 CONSUMER GROUPS PERCEIVED AS SUITABLE USERS OF A PORTABLE IPD

There was some agreement across groups concerning which consumer groups would find a portable IPD useful. The trend was that it might be useful for others, but not for oneself; for those who had some difficulty in crossing roads, but not for the average able-bodied pedestrian. Education about the risks of crossing the road may help adjust perceptions.

The visually restricted group were most positive about the portable IPD, and seemed to view it as visual sense replacement. Also, elderly pedestrians appeared to perceive it as a 'top up' to compensate for their failing faculties. Suggestions for likely users included, foreign visitors and the hard of hearing. This confirms that people believed that one needs to have a particular problem or deficiency before considering using a portable IPD. Unfortunately, this may lead to a stigma becoming attached to users, and that would impede social acceptance.

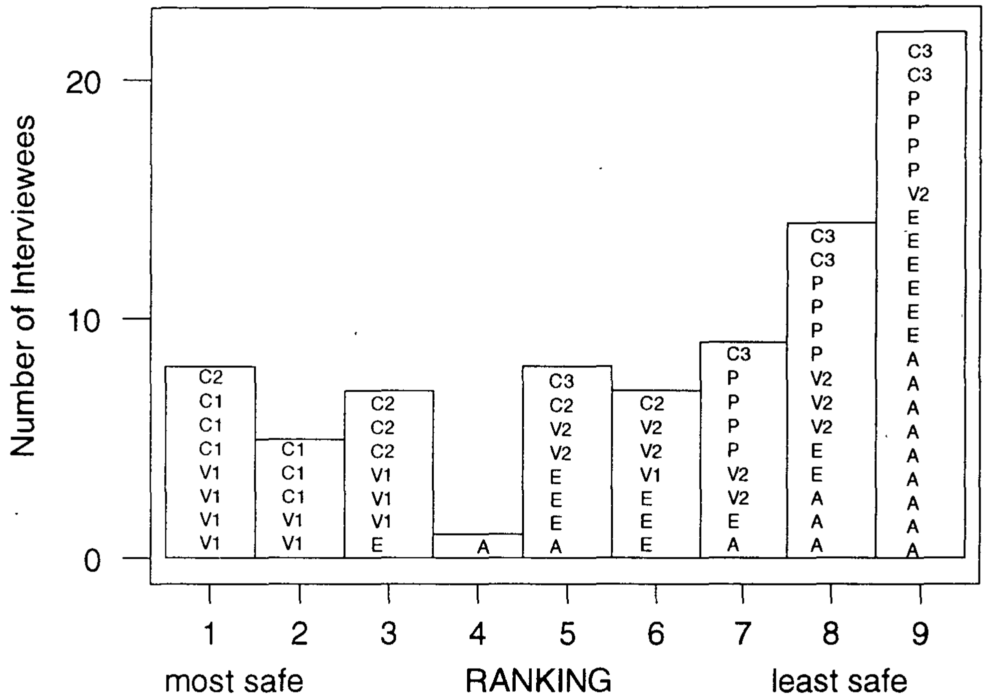
The ranking task, summing the positive, neutral and negative comments made in the bubble drawings, and the follow-up questionnaire gave more quantitative results on the acceptability of a portable IPD. Table 10 shows the rank of mean ranks for each sub-sample that completed the task on scales of perceived safety and like of use and the overall rank of mean ranks for all respondents. This shows that compared to other facilities, the adult, elderly and parents groups do not believe the portable IPD is safe.

Table 10. *Rank of the Mean Rank for Sub-Samples and for the Whole Sample for the Portable IPD on the Scales of Perceived Safety and Like of Use.*

SCALE	RANK OF THE MEAN RANK					
1-9	Adult	Elderly	Vis.Res.	Parents	Children	All
Most safe-Least safe. n = 83	9	9	4	9	3	8
Most like-Least like. n = 51	9	8	n/a	n/a	4	8

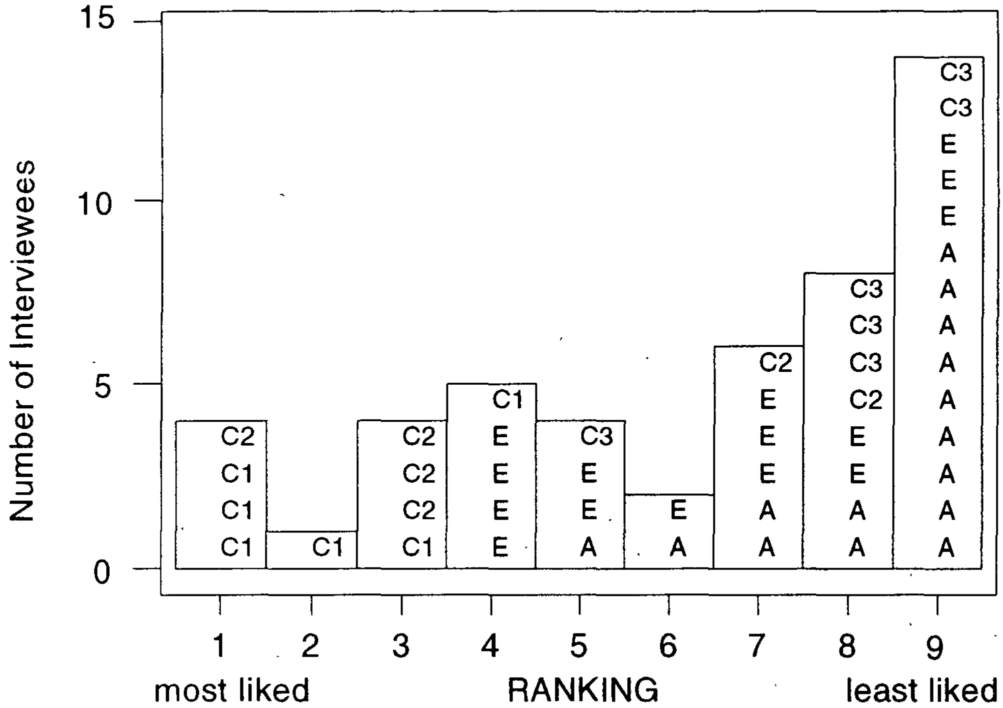
Closer inspection of the rankings on the scale of perceived safety, shown in the histogram in figure 14 illustrates that the less independent visually restricted and younger child sub-samples have ranked it very favourably. Figure 15 shows the rankings for the like of use scale which was only completed by the adult, elderly and child groups. This shows that it is again the youngest children who have ranked the portable IPD favourably.

Figure 14: Histogram of the 'Perceived Safety' Rankings for the Portable IPD, Identifying the Responses of All Sub-Samples'




```
A = Adult    n = 15
E = Elderly n = 16
V = Visually Resticted n = 20
    V1 = less independent group
    V2 = more independent group
P = Parent   n = 12
C = Children n = 18
    C1 = 10-11 years old
    C2 = 11-12 years old
    C3 = 13-14 years old
```

Figure 15: Histogram of the 'Like of Use' Rankings for the Portable IPD, Identifying the Responses of the Adult, Elderly and Child Sub-Samples'



A = Adult n = 15
E = Elderly n = 15
C = Children n = 18
C1 = 10-11 years old
C2 = 11-12 years old
C3 = 13-14 years old

Kruskall-Wallis one-way analysis of variance tests were carried out on these two sets of data to test the following null hypotheses:

> There will be no significant differences between the sub-samples rankings of the portable IPD on the scales of a) perceived safety and b) like of use.

Both null hypotheses were rejected. For the data in figure 14 on perceived safety of the IPD the value was $H = 48.58$, $p < 0.001$. A similar result for the data in figure 15 on the like of use of the portable IPD was achieved $H = 26.03$, $p < 0.001$. Appendix 22 shows the Z values of each sub-sample for the Kruskall-Wallis tests, and these confirm that the adult sub-sample are more negative about the IPD than the other sub-samples, and the two youngest child groups and the less independent of the visually restricted groups are more positive about the IPD than the other sub-samples or groups.

Positive responses may have been caused by interviewer expectancy bias. Every effort was made by the interviewer to present the IPDs in an unbiased way. However, an interview set up to elicit responses on any product may suggest to interviewees that the product is important to the interviewer, and hence interviewees may try to please the interviewer by giving positive evaluations. Alternatively, the positive responses may reflect these groups' more open-minded attitude. The less independent visually restricted group's need for mobility may have driven their enthusiasm, and young children are usually more adaptable and accepting than most adults. To improve social acceptance as adolescents and adults it may be important to introduce the idea of a portable IPD to young children. Due to the small sample sizes in the groups within the sub-samples these results should be treated as tentative. However, they may be indications that offer some interesting hypotheses, worthy of further investigation.

People may have made unfavourable rankings because they did not fully understand how the IPD would work, and consequently felt unable to compare it to existing facilities. Also the portable IPD is unlike other pedestrian crossing facilities in that it is a personal rather than a public aid. For these reasons it may have been more useful to compare the portable IPD with other personal safety devices like driver air bags than with pedestrian crossing facilities.

Table 11 shows the number of negative, neutral and positive statements made about the portable IPD in the bubble drawings for the sub-samples that completed this task. As can be seen there are approximately the same number of positive, negative and neutral comments. However, there is a different pattern of responses between the groups. The adult group again show most negativity towards the IPD; the children show most positivity.

Table 11. *The Number of Negative, Neutral and Positive Comments Made About the Portable IPD by Various Sub-Samples of Pedestrians in the Bubble Drawings.*

	Number of Comments			
Sub-Sample	Negative	Neutral	Positive	Total
Adults	10	3	2	15
Elderly	2	8	8	18
Parents	4	6	2	12
Children	6	2	11	19
Totals	22	19	23	64

The follow-up questionnaire, completed by all sub-samples except the children, included questions on consumer groups that would find an IPD useful. Six groups of pedestrians were assessed: self, elderly, children, visually restricted, physically restricted and people in general, and responses could be, yes, perhaps or no. All interviewees, except two of the parent group returned their follow-up questionnaires.

Group and overall results are given in appendix 23 and the main results are summarised below.

- In all categories, a large percentage of people answered 'perhaps'
- The adult sub-sample gave few 'yes' responses for most of the groups that were assessed, and all of them rated a portable IPD as not useful for themselves. However, 60% thought it might be useful for the visually restricted.
- Overall, more people answered 'no' for the 'self' group than any other group.
- The majority of people in all of the sub-samples thought a portable IPD would or could be useful to the elderly (this included the sample of elderly people).
- 50% or more of all sub-samples thought a portable IPD would be useful to visually restricted pedestrians. More than 75% in each sub-sample thought it would or could be useful This was the highest for any group and included the sample of visually restricted people.

- The majority of people in all of the sub-samples thought a portable IPD would not be useful for people in general. However, most sub-samples also had a reasonably high percentage of perhapses.

The large percentage of people that answered 'perhaps' may have felt that they did not have enough information to form a considered opinion. These result show that the majority of respondents believed that a portable IPD would or could be useful to all named groups of pedestrians, and 16 of 62 or 26% thought that it would definitely be useful for people in general. This conclusion is contrary to the negativity reported previously that was expressed during the interviews and the ranking task.

Six Kruskal- Wallis one way analysis of variance tests for unrelated data were carried out in order to test the following null hypotheses. The data were converted to ordinal level by assigning responses of 'no' 0 points, 'perhaps' 1 point and 'yes' 2 points.

> There will be no significant difference between the four sub-samples' ratings of the usefulness of the portable IPD for the a) self b) elderly c) children d) visually restricted e) physically restricted and f) people in general groups assessed.

Null hypotheses for a) and c) were rejected and the others were accepted. The H values with the corresponding Z values for each group assesses are shown in appendix 24. The results show that the samples differ significantly among themselves for the 'self' ($H = 24.66$, $p < 0.001$) and 'children' ($H = 9.37$, $p < 0.05$) groups assessed. The Z values for the 'self' group assessed show that by comparison to the other sub-samples the adults found it less useful for myself, and the visually restricted sub-sample found it more useful for myself. The Z values for the 'children' group assessed show that the adult sub-sample have again found the portable IPD less useful, and the parents have found it more useful.

It is surprising that the parents, (who had been quite negative in the interview) found the portable IPD more useful for children, and that the adults tended to think it would not be useful. Parents were asked to think about their child using a portable IPD before sending back the follow-up questionnaire, whereas adults were asked to think about themselves. For this reason parents may have given a more considered opinion about children than the adults. Further research to clarify these results is required.

In addition, a Friedman test for related data was carried out to test the following null hypothesis. The Friedman test does not allow missing values so these (4 in all) were given values of 0.

> There will be no significant difference between the six groups assessed in the ratings of usefulness of the portable IPD.

The result was $S = 35.24$, $p < 0.001$. Hence, the null hypothesis was rejected as there was a very significant difference between the sample's assessments of the six groups. The results are shown in appendix 25, and in summary show that the whole sample assessed the portable IPD as more useful for the visually restricted, and less useful for people in general. These results support the conclusion outlined above that, at present, the IPD is perceived as only suitable for people with some kind of impairment.

In summary, these results show that by comparison to other existing pedestrian crossing facilities, the portable IPD is not generally perceived favourably. However, people have not dismissed it out of hand. The bubble drawing results show that a number of people, (especially in the adult sample), have worries concerning IPD use. But, the follow-up questionnaire results suggest that the majority of people are willing to consider the portable IPD for some groups of pedestrians. The general perception is that the able bodied do not need a personal pedestrian aid, but with knowledge of the portable IPD, people may become less sceptical.

5.6 AN ACCEPTABLE PRICE FOR A PORTABLE IPD.

The follow-up questionnaire asked respondents how much at most they would be willing to pay for a portable IPD. Five alternative prices were given. Table 12 shows the number of respondents in each sub-sample that answered for each alternative amount. No response refers to those people who returned the questionnaire but did not complete this section of it.

Table 12. *The Number of Respondents in Each Sub-Sample that answered in the Follow up Questionnaire that They Would Pay, at Most, one of Five Given Amounts.* *n=63*

GROUP	MAXIMUM AMOUNT RESPONDENT WOULD PAY					
£	5	15	45	135	400	no response
	Number of Respondents					
Adults	2	5	2	1	2	3
Elderly	0	4	7	2	0	5
Vis.Res	3	2	5	4	1	5
Parents	0	3	3	2	0	2
Total	5	14	17	9	3	15

As can be seen 15 or 24% of respondents did not answer this question. There were several reasons for this: some of the visually restricted pedestrians felt that as IPDs were an essential mobility aid they should be supplied free to them, other people had no idea of an appropriate amount and some did not offer an amount because they thought it was not practical at all. Excluding those that did not answer this section there were 48 responses; of these, the mode amount was £45, and 29 or 60% were willing to pay at least £45.

Discussion during the interviews suggested that people chose a price by comparing the perceived usefulness of IPDs with the perceived usefulness of other devices. Apart from this kind of calculation, fixing an amount one would pay depends partly on how much money one has. There are ethical considerations if people who need a portable IPD cannot afford one. The problem occurs in defining level of need; there would be no point in buying a portable IPD if it was not needed at some level. The political implications of these points are beyond the scope of this thesis. However, further discussion of costs and benefits is made in section 10.4.

5.7 ATTITUDES TOWARDS THE FIXED IPD

In the time set aside to discuss the fixed IPD, limited information was given. This may be because the portable IPD was perceived as a more novel innovation, and hence people preferred to talk about it. The fixed IPD was perceived as similar to existing public facilities because it is not a personal aid.

The adults, parents and the oldest children suggested that the fixed IPD had no real advantage over a pelican crossing because it did not stop cars. It appeared that these pedestrians were most concerned with expediting their journey. Parents felt that their children would probably like using fixed IPDs because they 'like to press buttons'. However, they said they would not let their children use it unassisted in case they did not use it sensibly.

The elderly, visually restricted and youngest children said that they would find a fixed IPD useful. Many of the elderly sample were worried about their ability to use it competently because they lacked confidence with technology. The visually restricted group suggested that it would be useful to have a lot of fixed IPDs, perhaps because they perceived them as enabling their independent mobility rather than as safety aids. However, they were concerned that fixed IPDs would not allow them enough time to cross the road, and might be prone to vandalism.

Despite some positive evaluations of the fixed IPD during the interviews, responses in the ranking task did not evaluate the fixed IPD highly compared to other facilities. Table 13 shows that it was ranked amongst the least safe by all groups; neither was it perceived as liked in use. It was, however, ranked more highly than the portable IPD. It is possible that, as with the portable IPD, most respondents ranked the fixed IPD less favourably because they had limited information about it.

Table 13. *Rank of the Mean Rank for Each Sub-Sample of Pedestrians and for the Whole Sample for the Fixed IPD on the Scales of Perceived Safety and Like of Use.*

SCALE 1-9

	RANK OF THE MEAN RANK					
	Adult	Elderly	Vis.Res.	Parents	Children	All
Most safe- Least safe n = 82	7	8	7	7	6	7
Most like- Least like n = 48	8	5	n/a	n/a	5	7

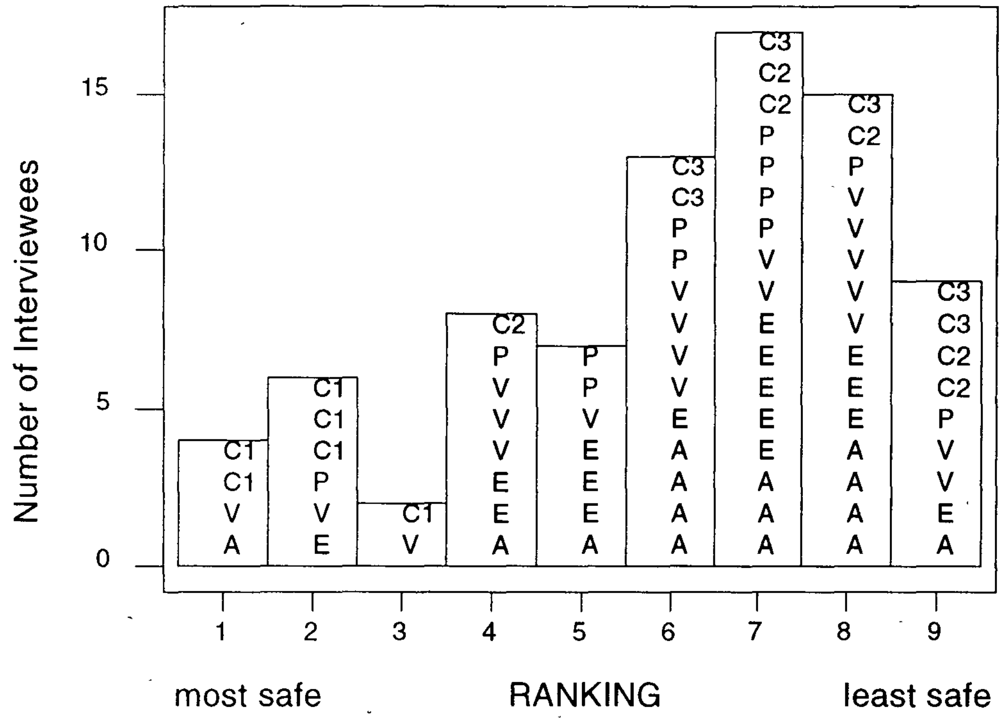
Figure 16 and 17 show that the youngest children and a few individuals in other groups ranked the fixed IPD favourably on safety and like of use. Kruskall-Wallis one-way analysis of variance tests were carried out on these two sets of data to test the following null hypotheses:

> There will be no significant differences between the sub-samples rankings of the fixed IPD on the scales of a) perceived safety and b) like of use.

Both null hypotheses were rejected. For the data in figure 16 on perceived safety the value was $H = 18.48$, $p = < 0.01$. A similar result for the data in figure 17 on the like of use was found, showing that again the samples differed significantly amongst themselves ($H = 13.72$, $p < 0.01$). Appendix 26 shows the Z values of each sub-sample for the Kruskall-Wallis tests, and the results confirm that the youngest child group are more positive about safety and like of use of the fixed IPD than the other groups.

As with the portable IPD, the favourable rankings may have been due to interviewer expectancy bias or open-mindedness. These conclusions are tentative because of the small group sizes. However, they do indicate areas of possible further research.

Figure 16: Histogram of the 'Perceived Safety' Rankings for the Fixed IPD, Identifying the Responses of all Sub-Samples'



A = Adult n = 15

E = Elderly n = 16

V = Visually Resticted n = 20

P = Parent n = 12

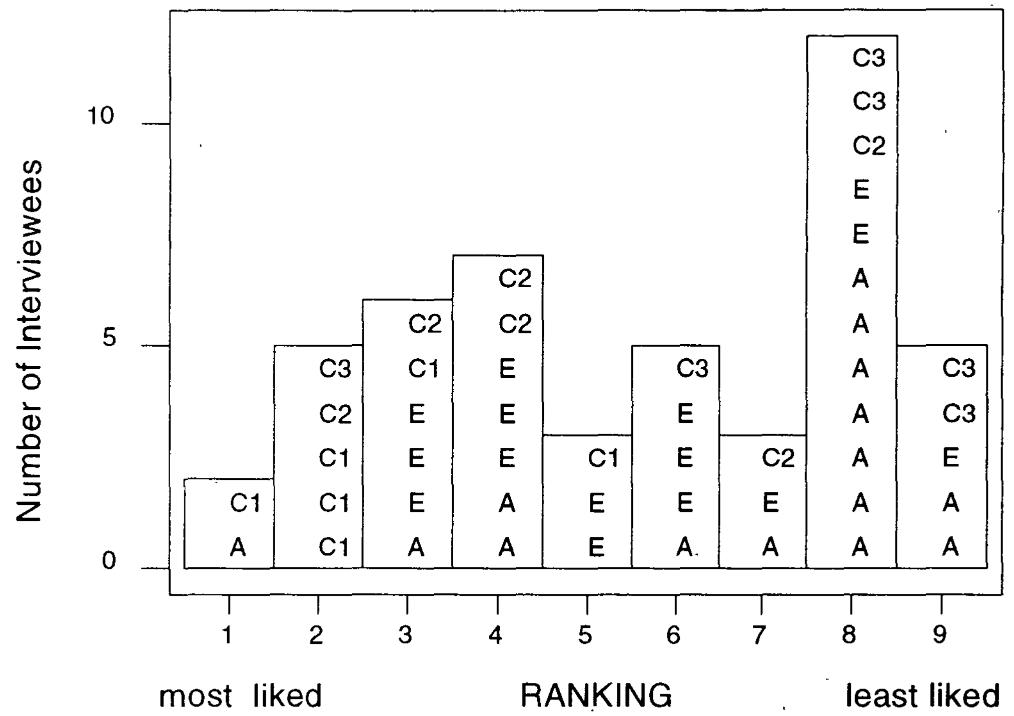
C = Children n = 18

C1 = 10-11 years old

C2 = 11-12 years old

C3 = 13-14 years old

Figure 17: Histogram of the 'Like of Use' Rankings for the Fixed IPD, Identifying the Responses of the Adult, Elderly and Child Sub-Samples'




```
A = Adult    n = 15
E = Elderly n = 15
C = Children n = 18
    C1 = 10-11 years old
    C2 = 11-12 years old
    C3 = 13-14 years old
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5.8 CONCLUSIONS.

In this section the results for each of the sub-samples interviewed are summarised. The overall conclusions for the whole sample are then outlined.

5.8.1 Adults Aged 18-60.

Adults showed a basic mistrust of technology and machinery, and were uncertain about how reliable an IPD would be. It appeared that this mistrust was connected to a need to feel in control of the environment. The portable IPD was not perceived as bestowing more control, nor was it seen to increase personal freedom. People felt in control by using and relying on their own faculties. Attitudes towards the portable IPD could change if it was shown that the extra information provided by the IPD would give its users more control.

None of this group felt that a portable IPD would be useful for them, although many thought it would be useful for some other groups of people, e.g. visually restricted, elderly and physically restricted pedestrians. This may be evidence of an attitude (discussed in chapter 3) that people feel they are safe and in control and more or less invulnerable to accidents, whereas others are not.

The interviewer's impression of this sample was that people were genuinely surprised that a device like the IPD would be considered as suitable for their needs. With discussion people understood the IPD's function, but still felt that they would cope with whatever arose in the road environment, without any aid.

5.8.2 Elderly Aged 65+.

The elderly said that they had difficulty negotiating the road environment. It seemed that coping with traffic was too much for them, and they wanted a simpler solution to their problems. Interviewees showed a diverse range of opinions, both during the interview and in their ranking of pedestrian facilities. Opinions often reflected individuals' specific concerns. This suggests that elderly pedestrians might benefit from the individual assistance that the portable IPD could offer.

Many of the elderly appeared to consider using an IPD as a back up to their own judgement. This may indicate that they perceived a need to supplement their failing senses. Also, many thought a portable IPD would be suitable for those with restricted vision.

The interviewer's impression was that the two elderly groups interviewed differed in their attitudes. The less mobile group often tended to get 'stuck' on specific issues and were generally more negative. Perhaps their limited mobility and failing health made them less self-confident and hence more dismissive and closed minded. Most of the written non-responders came from the less mobile group, indicating that on average they may have been less intellectually active than the other group. The more mobile group were generally more positive about IPDs.

5.8.3 Visually Restricted.

This group reported difficulties in negotiating the road environment; pavement obstacles were a particular problem. Confidence was an important issue for visually restricted pedestrians; the less confident were perceived as being controlled by the environment and having only limited mobility, the more confident were perceived as battling to control the environment and having more mobility. In summary, as one person put it, 'You're trapped or you take courage'.

Interviewees appeared to prefer pedestrian facilities they could use independently. If the portable IPD was perceived as increasing independent travel it was accepted. The fixed device was viewed positively. However, several people commented that there would need to be so many of them. This suggests that the fixed IPD was perceived as a device that restores independent mobility, rather than one which increases crossing safety at selected potentially dangerous locations. For this reason there were forceful arguments to give rather than sell portable IPDs to all visually restricted pedestrians who needed one, because it would be immoral not to do so.

The visually restricted identified locating the kerb as an important function for the IPD. However, there were still worries concerning interviewee's confidence in using the device on the road. Many said they would need to be taught how to use it, and there was some evidence of the fear of losing dependency.

The majority of people in this sub-sample believed that the portable IPD could be useful for all of the groups of people investigated, except people in general. This may suggest that visually restricted pedestrians believe that the IPD can make up for any deficiency suffered by people, but people with no deficiency would not need any aid.

The interviewer's impression of this sub-sample was that they earnestly wanted some improvement in their mobility, so they were ready to be positive. However, the more independent group had a more 'worldly' approach that lead them to regard any new aids with scepticism.

5.8.4 Parents of Children Aged 5-9.

Parents thought that their children could act irrationally and they did not think that they would use a portable IPD responsibly. Personal responsibility appeared to be an important issue in two ways. Firstly, in terms of whether or not the child could take responsibility for their actions, and secondly, parents' own responsibility to the child to protect him or her. Also, it was felt that the portable IPD would not allow children to learn how to cope on their own.

The follow-up questionnaire contradicted the interview findings in that most respondents said that the portable IPD would or could be useful for all pedestrian groups, except themselves. Perhaps the negativity shown in the interview was merely a thorough concern for their children's safety, and later reflection produced a less extreme response.

The interviewer's impression was that these parents were primarily concerned with beginning to let their children travel independently on the road, and they felt that the IPD was added complication.

5.8.5 Children Aged 10-14.

There appeared to be a gradual change in attitude with age. The older children were more aware of their environment, and that they had responsibilities. Also, they were more concerned with convenience. Their attitude towards being a pedestrian was often a direct challenge to authority and they often talked with some bravado. Perhaps by this age children feel they have mastered the challenge of our modern road environment and are proud of their new found independence.

Concerning attitudes towards IPDs, children became increasingly sceptical with age. The youngest group were very accepting and confident about IPD use, the middle group had some concerns and the oldest group appeared to view it as taking away their personal independence. It seemed that the older children did not perceive the IPD as helping them control their environment. Perhaps IPDs were seen as yet another object of authority telling them what to do. Adolescent conflict can be caused by the drive to be independent, and mobility is a very important step in becoming independent. Further research into the change of attitude towards pedestrian devices with age would be useful.

From the interviewer's point of view the oldest group did appear more negative than the other groups. This is a feature of early adolescence, and it is possible that they gave negatively biased responses based on interviewer expectancy; they downgraded the IPD because they believed the interviewer wanted them to give it a positive response.

5.8.6 Overall Conclusions for the Feasibility of IPDs.

84 pedestrians were interviewed in order to assess attitudes towards the IPD. It appears that most people feel that the road environment is a natural, everyday surrounding which they should, and do, cope with. It is the modern equivalent of their hunting ground where they must be in control. Hence, they have no need for IPDs. However, those people who have experienced problems in negotiating the road environment recognise the benefits of IPDs. Elderly people have often experienced a deterioration of skill, and the visually restricted live with a mobility handicap. Young dependent children also perceive the road environment as challenging, but adolescent children gradually develop the self-sufficient attitude of an adult. It seems that people perceive IPDs as a substitute for some loss of faculties rather than a performance aid.

The lack of knowledge about the nature and functions of the IPD makes people cautious about how useful it could be. The less the perceived personal need the more cautious they are. Many people are wary of new technological devices, and these have not yet had an impact on the road environment, (especially for pedestrians). With time, knowledge, experience and marketing there is some evidence that these attitudes may change, and the IPD will become more socially acceptable.

PART 3

PEDESTRIANS' ROAD CROSSING BEHAVIOUR

CHAPTER 6. PEDESTRIAN BEHAVIOUR

CHAPTER 6. PEDESTRIAN BEHAVIOUR

6.0 INTRODUCTION

The aim of this chapter is to outline how some of the existing research on pedestrian behaviour will help in the design of Intelligent Pedestrian Devices (IPDs). Pedestrian behaviour is defined as performance on journeys made on foot. It is a 'complex series of responses performed in an attempt to cope with an ever changing situation.' (Chapman, Wade and Foot, 1982).

Despite several reviews of pedestrian behaviour, (OECD, 1969; Shinar, 1978; Chapman, Wade and Foot, 1982; Heraty, 1986) there is still much we do not know about how pedestrians cross the road. Researchers (Firth; Howarth; Rennie and Wilson in Oborne and Levis 1980) point to a number of methodological problems in studying pedestrian behaviour, which may partly explain this.

The observed behaviour of pedestrians is a result of a great deal of cognitive processing by individuals. Understanding these processes will aid understanding of behaviours like gap acceptance. In this chapter the cognitive processes are outlined and road crossing behaviours are discussed in order to increase our understanding of what might be expected from an IPD by pedestrians.

A 'direct relationship between road-user behaviour and accidents is not yet proven', we have still 'to ascertain whether the behaviour of a driver or a pedestrian was "odd" at the time of an accident, or whether a driver's or pedestrian's hazardous behaviour was typical but led on only this occasion to an accident.' (Heraty, 1986). However, examination of some of the research on pedestrian accidents and exposure could be useful.

Pedestrians are not a homogeneous group, and their behaviour may be affected by a number of different variables e.g. age, locomotor and visual ability. For this reason, research on several different groups of pedestrians in areas of specific interest e.g. walking speed, is outlined.

6.1 COGNITIVE PROCESSES

Cognitive processes relevant to the pedestrian task like perception, attention, memory and thinking are always difficult to study because they are internal processes that must be inferred from observed behaviours. Helbing (1991) points out that individual pedestrians' decision-making is usually based on utility maximisation. However, a model of pedestrian movement could never be valid as:

- people are sometimes in non-standard situations
- optimal strategies may not have been learnt yet
- movement might be affected by emotional or other factors
- all behaviours have some degree of irregularity.

Helbing's task to build a mathematical model for the movement of pedestrians makes it necessary for him to simplify observed behaviours. However, in reality, pedestrian behaviour is the result of a complicated combination of cognitive, social, individual and environmental factors that are impossible to separate. The following outlines the cognitive processes involved and assesses the affect of individual user's risk perception.

6.1.1 Processing Information from the Environment

Pedestrians process information about their environment continually. Older and Grayson's (1974) work is perhaps the most comprehensive in terms of outlining the cognitive processes involved in crossing the road. Figure 18 below illustrates the various stages that may take place during crossing. The authors point out that these stages overlap and may be repeated several times during any one crossing.

It is possible that a portable IPD would need to simulate observation, perception and judgement of the road environment in order to produce a decision and advise its user when a safe gap was available. This should lead to a reduction in the accidents that were formerly caused by errors in pedestrians' cognitive processing. For example, accidents caused by pedestrians who were not competent in recognising and compensating for differences in vehicle speeds (Gallagher and Janoff, 1972).

Figure 18. Stages Involved in the Road Crossing Task.

```
                                                          Stage

                        |-Location selection                1
                        |
                        |
          |-Pre-crossing |
          |             |                     |-Observation   2
Road      |             |                     |-Perception    3
        - -|            | --Time selection
crossing  |                                   |-Judgement     4
          |                                   |-Decision      5
          |
          |-Crossing                                          6
```

(from Older and Grayson, 1974).

Recent work (Russell and Hine,1996) has outlined the difficulty in assessing people's reluctance to cross at some locations. The decision concerning when and where to cross lies ultimately with pedestrians, and there are no behaviours that can always predict when and where a pedestrian will cross. Therefore, portable IPDs will not be able to rely on behavioural cues to predict an imminent crossing. Hence, users may need to input a request to get information about the safety of crossing. The IPD could offer information about the safety of crossing all roads adjacent to the user continuously. However, in many road environments e.g. junctions, this could cause an overload in information which would be difficult, if not impossible to convey to the user.

If users must request information, they will have to decide when and where they want to cross. This involves some cognitive processing of information from the surrounding environment e.g. perceiving that there is a road that needs to be crossed. This would mean that the IPD could not save accidents that occur due to pedestrians not attending to this kind of basic information. Also, having to ask the IPD for information might restrict its use, and hence efficiency. A failsafe mechanism which provides a strong warning signal to the user when a high risk situation is registered (regardless of whether or not it had been asked for information) could help solve these problems.

The theory of planned behaviour (Ajzen, 1991 in Evans, 1994) has been applied to pedestrian road crossing behaviour. The theory suggests that intentions to act are the primary determinant of any behaviour, and intention is governed by beliefs about a) the planned behaviour and b) perceived behavioural control of the situation. Evans' research found that the latter was the most important component in explaining road crossing intentions. The portable IPD may affect its users' perception of the behavioural control they have when crossing the road.

Studies have shown us the complexity of the cognitive abilities that we can employ when dealing with the road environment (Goodwin et al., 1974; Reinhardt-Rutland, 1991), but we do not know if people would continue to process information if the IPD was doing it for them. If users do not continue to process information their level of performance may decline. Experience with other labour saving devices like calculators has shown that we learn to trust the information it gives us, and do not bother to check its accuracy. Whether it would be the same with a device that was responsible for personal safety is difficult to say. The interview research reported in the previous chapter goes some way towards answering these questions.

6.1.2 Risk Perception

Human decision making about crossing the road does not depend on calculations of probabilities (Yates, 1992). For example, people will accept higher levels of risk when in a hurry. If users' judgement, based on their overall perception of risk, differed from the IPD's it may cause confusion and result in a deterioration in road crossing performance instead of an improvement.

Conversely, the portable IPD could work as a learning device. Users and non-users could use the advice about when it is safe to cross as a model of safe behaviour. People are becoming accustomed to learning how to master old and new skills with new technology. However, it is not clear if they would accept an IPD's advice as superior to their own skill. Again the interview research on the social acceptance of an IPD in chapter 5 attempted to address these questions.

Some theories of risk perception suggest that we each have an internal mechanism that balances the amount of risk that we are prepared to take. Societal norms of safety can, for example, affect the way we perceive risk (Wilde, 1981). If this is true then any saving in risk made by using an IPD might be 'spent' in some other way.

However people perceive the risk of crossing the road, the IPD is likely to change that perception in some way, e.g. by making people feel safer. The repercussions of this are difficult to predict.

6.2 CROSSING BEHAVIOUR

In this section examination of pedestrian speed, delay, strategy, gap acceptance and temporary impairment is made in order to increase understanding of what might be expected from an IPD by pedestrians.

6.2.1 Pedestrian Speed

> There are two classes of pedestrian in these days of reckless driving: the quick and the dead. Lord Dewar.

At the most basic level, the IPD will need to ensure that its user has enough time to cross the road safely. This will involve calculating the expected time of arrival of vehicles at the user's projected path, and to some extent this depends on pedestrian walk speed.

Research in the laboratory carried out by Murray et al (1966) showed that the mean 'fast' walking speed for men was 0.67 metres per second (m/s) faster than their mean 'free' or preferred walking speed. Hunt and Abduljabbar (1993) quote pedestrian mean walking speed to be 1.35 metres per second, and Kurosawa (1994) found that walking at men's preferred velocity of 1.34 metres per second calls for low demands on attention. This would leave maximum attention for the crossing task.

Boles (1981) quotes an unpublished study by Hirsch which observed that pedestrians avoid altering their preferred walking speed when confronted by an obstacle on the footway. However, pedestrians are often observed to increase their walking speed in order to cross the road more quickly (Older and Grayson, 1974). In fact Older and Grayson found that pedestrians will increase and decrease their walking speeds several times in the course of one crossing in order to negotiate the various lanes of traffic. Hunt and Griffiths (1991) showed that pedestrians often adapt their crossing speed to accept smaller gaps.

In order that pedestrians may cross the road in congested conditions, many adopt a 'duck and dive' strategy, pausing at each traffic lane and then accelerating across each one in turn. This saves time either waiting at the kerb or moving to a 'safer' crossing place. IPD users would be instructed to cross, only when a safe path across the entire road is available. Whether this would help habitual jaywalkers is not known.

Individuals' walking speeds may vary from day to day, or within the same journey. For this reason it would be necessary to calibrate the IPD to the pedestrian's walking speed. However, users would need to be aware that they should not decrease their walking speed after beginning to cross the road. Continual monitoring of the pedestrian's speed might help.

Research has shown that pedestrian speed is affected by the pedestrian's environment, (Boles, 1981) the time of day, (Boles, 1981; Walmsley and Lewis, 1989) the density of pedestrians, (Boles, 1981; Gifford et al, 1977) the age of the pedestrian, (Dept. of Env., 1976; Waterhouse, 1982; Walmsley and Lewis, 1989) the sex of the pedestrian, (Gifford et al., 1977; Walmsley and Lewis, 1989; Wirtz and Ries; 1992) the cultural background of the pedestrian, (Morall et al., 1989) the size of the city walked in, the amount of congestion and the weather (Walmsley and Lewis, 1989). None of these variables would cause any problems if the IPD continually monitored each pedestrian user's walking speed.

6.2.2 Pedestrian Delay and Strategy

The traffic engineer must decide which type of pedestrian facility suits the circumstances. Delay to both driver and pedestrian need to be taken into consideration in this decision.

Crossing facilities (discussed in chapter 2) can reduce or cause delay to pedestrians. Delay is caused by waiting for the flow of vehicles to be interrupted and/or the necessity to make detours. Bridges and subways are unpopular for several reasons, including the delay they can cause. People often prefer the less safe but quicker road level crossing. It seems that 100% usage of a bridge is only likely to occur when the bridge journey takes no more than three quarters of the time required for a road level crossing (Department of Scientific and Industrial Research 1963 in Chapman, Wade and Foot, 1982), and subway use depends on people not having to go out of their way (Dernellis and Ashworth, 1994). Personal safety is also an important reason for lack of use.

At pelican crossings it has been found that pedestrians will often cross outside the pedestrian phase (Dept. of Environment, 1976; Hunt and Al Neami, 1995), particularly if the signal timings are disadvantageous to the pedestrian (Retzko and Androsch, 1974). Pedestrians may ignore designated crossing facilities if they cause too much delay.

It seems that pedestrians are often willing to trade-off safety for reductions in delay. It is therefore 'imperative to assess the impact of motorised vehicles on pedestrian safety and delay' so that a measure of acceptable delay can be found (Song et al., 1993). The following typology of pedestrian behaviours illustrates pedestrians' responses to the road crossing task:

A- Double Gap Crossing in which the pedestrian does not begin crossing until they are sure they can cross the whole width of the road without stopping.

B- Risk Taker Crossing involves accepting a gap in the near traffic stream followed immediately by acceptance of another gap in the far traffic stream, or followed by an adjustment of his/her position with regard to another gap in the far lane.

C - Two Stage Crossing occurs in wide streets which have a centre median or refuge where the pedestrian may wait for an acceptable gap in the far stream of traffic.

D - Walk 'n' Look Crossing happens when the traffic flow is high. The pedestrian desiring to cross, walks along the pavement whilst also looking for a safe gap in the nearside traffic. On reaching the centre he or she may wait for an acceptable gap on the far stream or walk along the centre line until an acceptable gap is available. This tactic produces limited delay and risk.

* Abridged from Song et al. (1993) p 298-301.

Type A crossings are a more cautious method employed by e.g. mothers with babies, elderly and disabled people. These naturally safety conscious people are unlikely to trade-off safety for less delay. They would prefer to travel to a pedestrian crossing facility if a double gap crossing is not possible. However, they may still benefit from using an IPD in cases where their judgement may be faulty.

Pedestrians using type B strategy could be described as displaying a low threshold tolerance for delay and a high risk taking threshold. For people using this strategy an IPD is likely to incur an unacceptable delay. An important benefit of the IPD in these cases may be in raising awareness of the risk-taking behaviour being used.

Type C crossings help reduce delay whilst still maintaining a reasonable level of safety. However, these crossings are restricted to a particular road environment. The IPD may be able to emulate a two stage crossing, but not without clear environmental signs e.g.. a refuge. If IPDs could not emulate two stage crossings then some people may feel that the resultant delay was not worth the extra safety afforded by the IPD.

Grayson (1975a) found that many adults seem to prefer selecting a time to cross rather than a location, in order to reduce delay. For an IPD to do this it would have to be able to indicate an appropriate time to cross whilst the pedestrian user is still mobile (as in the type D Walk 'n' Look strategy outlined above).

Grayson (op. cit) also showed that further attempts to reduce journey delay are made by adult pedestrians in their frequent diagonal crossings of the road (i.e. crossings which are no perpendicular to the kerb). The portable IPD could take this into consideration when calculating gaps. However, as it would be difficult for the IPD to predict pedestrians' intentions, it may be better to assume the simpler, right angled crossing.

Crompton (1979) found that a significant number of pedestrians felt impatient about their delay in crossing the road. Random and refuge crossings had the highest impatience and worry scores. This was perhaps due to the pedestrians' knowledge that they had no control over the length of delay they were likely to experience. The portable IPD will not change this situation, but it may help educate users about which places are likely to be the most expedient for crossing the road. Research reported in the next sub-section has shown that long delays in crossing the road may result in pedestrians accepting shorter gaps.

Finally, the strategy used by a pedestrian depends on a number of personal and environmental factors. For example, Russell and Hine (1996) note that there are physical and psychological explanations for people's choice of crossing place and, Song et al. (1993) identifies nine vehicular traffic types that will affect pedestrian crossing behaviour. Each crossing is a complex interplay of many of these factors

6.2.3 Gap Acceptance

Early work on pedestrian gap acceptance found that people are more concerned with time gaps than distances (Cohen et al, 1955). This would seem sensible as arrival time is most important in ensuring the pedestrian avoids a conflict. Pedestrians calculate subconsciously when the vehicle will arrive at their projected crossing place. A gap that is perceived as safe might depend partly on this calculation, and a variety of other factors.

Cohen (op. cit) found that 50% of pedestrians who crossed at a refuge accepted a gap of at least 4.5 seconds; no-one accepted a gap of less than 1.5 seconds or required more that 10. 5 seconds. Ashworth's (1971) summary puts 'critical gap acceptance' at between 2 and 6 seconds. It has been found that larger gaps are required by: older pedestrians (Harrell and Bereska, 1992a), females and large groups of pedestrians (DiPietro and King, 1970), people accompanying an infant (Harrell and Bereska, 1992a), when there is a high volume of traffic (DiPietro and King, 1970., Hughes 1989), with slower pedestrian walking speed (DiPietro and King, 1970., Soong, 1982), with higher vehicle approach speeds (Soong, 1982) and higher levels of ambient lighting (Gallagher and Janoff, 1972). Less observable features like willingness to accept risk will also have an impact on gaps which are deemed acceptable.

The IPD would not consider all these variables. Calculations are likely to be based on pedestrian and vehicle speeds etc., and exclude 'human elements' which are impossible to predict for individuals. This will sometimes result in the IPD advising pedestrians not to accept a gap that they would have accepted themselves. This is sensible in terms of safety, however, it will add to delay. In cases where the motivation to avoid delay exceeds the desire for safety advice, pedestrians may disregard the IPD.

Research on pedestrian delay (Hunt and Williams, 1982., Hunt, 1990) has shown that it is lower at random points on the road network than at crossing facilities. It is considered that pedestrians become impatient when delay exceeds 30 seconds (Department of Environment, 1973). 'Although any relationship between delay and risk taking remains unproven, observations of pedestrian behaviour indicate that some pedestrians are prepared to accept smaller gaps in traffic flow as waiting time increases' (Hunt, 1990), and on one leg of crossing if there is a larger gap on the other leg of crossing (Hunt and Abduljabbar, 1993). This willingness to accept different sized gaps might prevent some people accepting the more consistent approach of IPDs.

6.2.4 Temporary Impairment

Temporary impairments can have a number of causes ranging from a broken leg to excessive alcohol consumption. Although the latter problem is not new, it has received relatively little attention until fairly recently. Everest (1992) reported that from a sample of 3,300 pedestrian fatalities, 38.4% had been drinking prior to their accident. Stark's (1987) analysis concludes that Blood Alcohol Content (BAC) was the primary cause of 82% of fatalities among pedestrians who had drunk alcohol, and that the effect of alcohol on risk of fatal accident is greater for pedestrians than for drivers.

Alcohol impairs motor, perceptual and cognitive ability generally, and therefore increases the likelihood of an accident. In comparison with other drugs, alcohol is relatively straightforward in its effect on performance. Drug abuse and the consumption of medications that do not require medical supervision may also lead to temporary impairment that increases accident liability.

The IPD would possibly help prevent some of the accidents caused by these kinds of temporary impairment. Some of the effects of drugs and alcohol e.g. bravado, might prevent optimal use of the IPD. However, others like lack of concentration could be helped.

6.3 EXPOSURE AND ACCIDENTS

There have been several reviews of pedestrian exposure (Hillman and Whalley, 1979; Todd and Walker, 1980; Mitchell and Stokes, 1982; Tobey, Shunamen and Knoblauch, 1983; Ward et al, 1994) which show that walking is a popular mode of transport. In addition, Mitchell and Stokes report that walking is almost universally available; 97% of people can go out on foot. However, they also note that on an average day only 70% of the adult population walk on a public highway, and 16% report having difficulty crossing roads. Walking is a medically recommended healthy activity, and unlike many other forms of transport, it does not pollute the atmosphere.

Exposure has been measured in many different ways including pedestrian/vehicle interactions and the time or distance an individual is walking in the road environment. Unfortunately, high levels of exposure are equated with high levels of accident risk. Goodwin and Hutchinson (1977) calculated that the accident rate per 100 million miles walked for pedestrians was second only to motorcyclists'.

With increased levels of exposure and hence risk, some pedestrians might prefer to take the precaution of using an IPD. However, people may not recognise that higher levels of exposure can produce higher levels of risk. Some groups of the population are more vulnerable than others and an increase in their exposure exacerbates the problem. A portable IPD might be able to help those with high exposure or accident rates. This might involve disseminating information about high risk groups and the likely increase in risks expected with increased exposure.

Sandels' (1979) statistical analysis of 907 injuries to pedestrians found that more than half of those injured behaved "correctly" just prior to the accident. This shows that often pedestrians are not in control of the situation. Giving this kind of information to pedestrians could act as powerful persuasion for IPD use.

Other research has shown what kinds of pedestrian behaviours have lead to accidents. Hakkert's (1976) analysis of 75 fatal pedestrian accidents considered 47 of them to be partly due to pedestrian error. Jonah and Engel (1983) reported the frequency of various pedestrian accident types, using a sample of 472 accidents. Those due to pedestrian behaviour are shown in table 14.

This shows that dart out and intersection dash accidents are the most frequent types. This is compatible with the ideas discussed above (section 6.2.2) concerning pedestrians' dislike of delay. Misjudgments, misperceptions or lack of observation may cause the pedestrian to behave rashly. We do not know if accidents and "normal" behaviour are related (Chapman, Wade and Foot, 1982). The IPD could give a warning if the user is under threat: an auditory warning might increase alertness at crucial times.

Table 14. *The Percentage of Pedestrian Accidents Caused by Various Types of Pedestrian Behaviour.*

Type of Accident	Percentage (n = 472)
Walking along road	5.6
Dart out/first half	14.3
Dart out/second half	5.4
Mid block dash	13.4
Intersection dash	18.1
Multiple threat	2.0
Work/play on road	4.5
Total	63.3

(Abridged from Jonah and Engel, 1983)

6.4 INDIVIDUAL DIFFERENCES

Each of us is unique, and hence our experience of being a pedestrian will be different. However, for convenience it may be useful to categorise people into groups that may experience similar problems, and consequently may have similar behaviour patterns. In this section some of the problems of elderly, child, mentally handicapped, physically disabled and visually impaired pedestrians are outlined, and the implications for the design and use of a portable IPD are discussed.

6.4.1 Elderly

Government statistics show that we live in an ageing population, in which the proportion of elderly people is set to increase for many years to come (Dept. of Transport, 1991c). The numerous physiological and psychological changes that take place with age affect pedestrian behaviour (OECD, 1985), and a combination of effects reduce the elderly's safety level (Carthy et al, 1995). Incidence of disability and frailty increases so that if the elderly pedestrian is involved in an accident the consequences are likely to be much more serious, or even fatal (Kingma, 1994). With a larger elderly population the pedestrian accident problem could worsen.

Grayson (1980) notes that although elderly pedestrians often suffer deterioration in abilities e.g. sensory deficiencies and slower reaction times, it is not clear how this deterioration leads to accidents. An observational study of elderly pedestrians (Wilson and Grayson, 1980) showed that there were only small age differences, most of which could be construed as safer for the elderly e.g. more head movements and longer delays before crossing. Studies by Harrell (1990, 1991a) also support the idea that the elderly pedestrian is more cautious, especially in particularly hazardous conditions.

Wilson and Rennie (1980, 1981) found that although elderly pedestrians said they had an overriding difficulty crossing roads, observational studies did not appear to support this. Harrell (1991a) suggests that the elderly may try to compensate for their skill loss, and actively seek to reduce their level of risk. If they are aware of their deficiency they take more care (Carthy et al., 1995).

An OECD report (op. cit.) notes that elderly pedestrians make 'spontaneous adaptions' to their environment. However, if a difficult or unusual situation is added, it can overload them. The above report concludes that we should not be content with spontaneous adaptions, but reassess and control the entire traffic system 'in such a way that the critical situations that may arise to elderly pedestrians are minimised'. This is a fine sentiment, however, a more realistic viewpoint is given by Russam (1977 in Chapman, Wade and Foot, 1982): 'a large part of the road layout is likely to remain virtually unchanged for several years to come'. Given this situation the portable IPD may be an effective alternative for elderly pedestrians to help cope with the unexpected.

Sheppard and Pattinson's (1986) interview study of elderly pedestrians involved in a road accident found that 63% did not see the vehicle before it hit them. In addition they found that 41% of those who did see the car that hit them said the vehicle was doing something unusual or unexpected. This included reversing into them, expecting the driver to stop or alter course, and moving off from a stationary position. As suggested above, failing to deal with these difficult situations may be largely due to the elderly pedestrians' declining faculties. In cases where a pedestrian fails in the observation part of the crossing task a portable IPD would prove invaluable as a warning that it was not safe to begin crossing. Where unexpected or unusual circumstances are the primary cause of a collision, the IPD could in many cases prevent an accident.

The walking speed of elderly pedestrians is much slower than younger pedestrians. Table 15 shows the mean and standard deviation, ordinary and fast walking speeds of men and women aged 79 years, using a sample of 81 men and 87 women from Gothenberg (OECD, 1985).

Table 15. *Mean and Standard Deviation of Ordinary and Fast Walking Speeds for Men and Women Aged 79.*

Sex	Mean and Standard Deviation	
	Ordinary speed in m/s	Fast speed in m/s
Men n=81	0.98 $\pm$ 0.25	1.21 $\pm$ 0.74
Women n=87	0.84 $\pm$ 0.33	1.05 $\pm$ 0.49

These figures show that most 79 year olds would not be able to reach the speed of 1.4 m/sec. required to safely cross a signalised junction. In most cases physical deterioration has lead to the point where crossing busy roads would be very difficult, and if the pedestrian did become involved in a potential conflict situation they would not have the acceleration to them help avoid the situation.

As discussed above (section 6.2.1) a slower walking speed would require a larger gap. Unfortunately, research (Holland, 1993) suggests that elderly pedestrians also consistently underestimate how long it takes them to walk set distances. In addition, they sometimes do not consider the second half of the road (Carthy et al., 1995). To ensure an adequate gap was available in both streams of traffic, the IPD would be calibrated to the individual pedestrian's present walking speed. In this way, the user could learn by observation the length of gaps that are safe for his or her walking speed.

Walking is a significant means of travel for elderly people (Dept. of Transport, 1991c). There is no doubt that the elderly person can face serious difficulties coping with the road environment today. The provision of road safety instruction for elderly people can help ameliorate the problems (Sheppard and Valentine, 1979). Although there is evidence to suggest that the problem is not that elderly pedestrians do not know how to act (Zeurcher, 1976).

Plowden (TRANSNET, 1990) points out that elderly people may be forced into a less active lifestyle 'forego(ing) non essential trips because they are too difficult, time-consuming or costly'. Since 'activity and sociability is central to the maintenance of morale in old age' travel problems are inextricably linked with other issues, for example, health, social services and planning. There are numerous reasons why walking should be made as easy as possible for elderly people. The IPD may give elderly people the confidence they feel they need to negotiate the existing road network and improve mobility.

Finally, some of the deficiencies suffered by elderly people which cause them to be vulnerable to road accidents might also affect efficient usage of an IPD. Many deficiencies like loss of hearing and sight could be adequately compensated for by an IPD, but changes in the central nervous system that reduce the ability to process data may interfere with the user's ability to respond to the IPD. Good ergonomic design would help reduce this problem, but care would need to be taken that increases in confidence were consistent with reasonable levels of cognitive ability.

6.4.2 Children

Using a multi-disciplinary approach to investigate the etiology of road accidents to children Christofell et al (1986) found that there are a wide range of contributory causes, ranging from hearing loss to lack of parking enforcement. Several researchers have identified exposure as a major factor in increasing the likelihood of a child being involved in an accident (Chapman, et al., 1980, 1981; Van der Molen, 1981). Malek et al (1990) note that when adjusted for traffic exposure, the risk of pedestrian injury to children is higher than any other age group. Other research (Lightburn et al., 1977) has shown that parents are often unaware of their child's rate of exposure, and Routledge et al. (1976) found that children typically report only 80% of their exposure.

Tight (1988) devised a questionnaire to measure exposure on journeys to and from school and concluded there was a need for road safety measures aimed specifically at the journey home from school. Hubbard-Jones et al. (1980) note from their study of crossing behaviours to and from school that 'the proportion of children crossing incautiously is ...appallingly large'. Childrens' exposure is found to vary according to several variables including the time of day, week and year; the type of road environment (Wade et al., 1981); the size of the town the child lives in (Pardo, 1988) and the sex of child (Chapman et al., 1980). Sadler's (1972) research showed that it was only the age of the child that determined whether or not he or she was allowed out. In deciding when to let their children out parents worry most about stranger-danger, but recognise that road traffic accidents are the biggest risk (Saville, 1993).

Exposure may be with or without other children and/ or adults. Some research suggests that travelling with other children may decrease the chances of an accident, as a group is more visible to a driver than an individual (Hubbard-Jones, 1980). However, other research suggests that the presence of an adult, while increasing safety, produces a deterioration of behaviour (MVA, 1989., Sandels, 1979). This is due to the child transferring their responsibility for achieving a safe crossing to the adult. The child is less aware and leaves the watching and judging tasks to adults. Also, recent research has shown that 'many children (are) reluctant to accept personal responsibility for their own safety' (Clayton et al., 1995).

The possibility of child pedestrians transferring responsibility for achieving a safe crossing has repercussions for the IPD. If IPDs are perceived by children as a 'magic talisman' that confers powers to the child rather than as a safety or learning device, then the child might believe, like a fairy tale, that they are protected from 'the beasts of the road'. Also, they may never develop the necessary skills to cope with the road environment. If the child then needed to travel without an IPD he or she could be seriously disadvantaged. Effective training regarding the nature and function of an IPD would be required.

If more exposure increases the possibility of an accident it would seem sensible to take extra precautions. Using an IPD might help redress the balance. Unfortunately, it is likely to be the poorer families, who could not afford to purchase an IPD whose children have higher exposure and accident risk. Malek et al (1990) point out that there is a lack of research into the causes of the high accident rate among children in poor communities.

Grayson (1975b) suggests that many accidents involving children are due to the child's lack of attention or lack of adequate supervision by a responsible person. He notes (Grayson, 1975a) that children's crossing strategies differ from those of adults. The main difference appears to be that children do not anticipate their crossing. Children typically wait till they arrive at the kerb to check traffic, and delay longer there (Routledge, 1975; 1976). With experience they learn to select crossing places with a clear view (Demetre and Gaffin, 1994). This type of behaviour is ideally suited to use of an IPD whereas the adult crossing strategies listed above are not.

Sandel's (1979) analysis of pedestrian accidents shows that 'dashing out' is the main cause for all children up to age 14. It would seem that crossing the road is not on the minds of children until they are faced with the road itself, and on some occasions even this does not cue the child to attend to the possible dangers. In this way the IPD's function to warn users about the potential danger of a road would be very useful for children.

Children undoubtedly have developmental limitations; for example, in their reaction to stimuli in peripheral vision (David et al., 1986). However, it is unclear how much unsafe behaviour is caused by children's lack of ability, and how much is caused by not perceiving the risk involved in their actions. Demetre et al (1992) argue that childrens' risky behaviour arises through lapses in attention and not because of perceptual-motor deficiency. Clayton et al (1995) show that children's perception of their environment is not concentrated on danger from traffic, but includes all potential threats to their safety. Vinje (1981) suggests that as children's developmental immaturity often incurs attentional deficits it is better to direct training towards controlling behaviour rather than teaching judgement and decision skills. She advises that children need 'an automatic detection process which is in the first place directed attention to the kerb'. The IPD could provide this service and hence may provide a valuable learning tool. A warning signal that advised the child that he or she was at the kerb might help the child become more aware of his or her need to pay attention.

Children who suffer disability as well as their developmental limitations, can be severely disadvantaged in coping with the road environment. For example, children with hearing loss were found to be thirty times more likely to be knocked down (MVA, 1989). The use of an IPD that gave a visual or tactile warning might help reduce this figure. Also, children who have personality characteristics that may make them more vulnerable to accidents, for example, high impulsivity, carelessness and unreliability (Manheimer and Mellinger, 1967), may benefit particularly from an IPD.

Many researchers have suggested that attempting to increase children's ability to cope with the road environment is only part of the answer. Changes to the road environment that suit childrens' abilities are also required. Van der Molen (1987) outlines the advantages of 'woon erven' or residential yards. Tight (1988) argues for 'new crossing facilities and traffic management measures'.

Unfortunately, England's research (in Wade et al., 1981) suggests that children have a basic misunderstanding of the degree of protection afforded by pelican and zebra crossings. Children appear to concentrate too much on the mechanics of using the crossing at the expense of continuing to monitor the traffic.

This suggests that children may be using their limited processing capacity to use the crossing facility. Although, Vinje (1990) suggests that this may be because children give too rigid an interpretation to the idea of 'priority'; to them it means they can count on having priority. It is possible that a similar cognitive overload problem would occur with the IPD. However, lack of monitoring of the road environment should not lead to an accident on such occasions, provided that the user paid attention to the IPD. The problem may be that if children become accustomed to crossing with an IPD and do not learn skills like judging appropriate gaps, then they may be more likely to be involved in an accident later, when not using an IPD.

An analogy with calculators can be made; it is widely held that children's use of them prevents development of the ability to do mental arithmetic. Basic mathematical skills are taught early in primary school, often without the use of calculators. Later, calculators are invaluable tools in helping students to perform complicated calculations. Perhaps the same strategy needs to be used with the IPD, young children learning to cross the road without an IPD or with adult guidance and older children using an IPD to help them.

Finally, education has traditionally played an important part in the development of children's pedestrian skills. Research suggests that practical training is the most effective. Downing and Spendlove (1981) found that a road safety campaign was associated with improved performance on tests, but had no effect on crossing behaviour. Sheppard (1990) showed that 7-9 year olds answered questions about road safety quite well, but their level of skill was low, suggesting that practical training is badly needed. Young and Lee (1987) used a pretend crossing task with 5 year olds, and found that their efficiency improved after only one hour.

Practical training of road safety skills may help reduce accident potential in younger children. An IPD may help in this practical training by advising supervised users which gaps are considered safe. To use the analogy given above, the IPD is used to check personal judgement at first in the same way as the answer to a sum might be checked with a calculator. Careful consideration would need to be given to the introduction of the IPD in this context in order to prevent children from becoming confused.

6.4.3 Mentally Handicapped

A recent Government initiative to transfer care for mentally handicapped people to the community will mean that it will be increasingly important for these people to develop pedestrian skills. Research has shown that it is possible to teach mild and moderately handicapped people pedestrian skills (Marchetti et al., 1983; Matson, 1980; Michie and Lindsay, 1987; La Grow et al., 1990).

La Grow et al (1990) conclude that there is no reason to believe that mentally handicapped people will not profit from training, and quotes research on the success some have achieved in driving cars. Methods of teaching pedestrian skills appear to be most effective if they involve in vivo techniques. Michie and Lindsay (1987) taught a number of target behaviours by modelling and role play, employing social reinforcement from the trainers. La Grow (1990) emphasised the importance of building skill and self-confidence and the gradual increment of situations with high sensory intake. In addition, he noted that a reasonable level of social skill, emotional stability and ability to solve perceptual problems is necessary. The latter of these, which would include such things as interpreting traffic signals, is found to relate to mental age.

With research suggesting that many mentally handicapped people can learn pedestrian skills, it would seem possible that many would be capable of using an IPD. Mentally handicapped people would still need to develop all the skills necessary to cross roads. However, use of the IPD might supplement these skills, facilitate learning about road crossing and improve confidence for the user.

6.4.4 Physically Disabled

There are many types of physical disability leading to a wide gradation of mobility handicap. Visual impairment is discussed under separate cover in the following section. Much of the literature on mobility for the physically disabled surrounds the need for motorised transport and the accessibility of the road environment (Institute of Civil Engineers, 1990; TRANSNET, 1990; Oxley, 1989).

Frye notes (TRANSNET, 1990) that 12% of the population are disabled in some way.

This includes a substantial number of elderly people whose physical abilities have deteriorated with the ageing process, and hence may not consider themselves disabled. Mitchell (Institute of Civil Engineers, 1990) quotes only 18% of disabled people as being under 50 years. Most disabled people (69%) have locomotor difficulties, while 41% have impaired hearing. Most can travel with assistance (92%), although many disabled people have low expectations concerning travel (Oxley, 1989).

Exactly how useful disabled people would find an IPD will depend on the type of disability they have. The 7% of disabled people who are wheelchair users are not likely to find it useful unless there are accompanying changes to the road environment that enable them to access the road more easily. Calibrating IPDs to walking speed will obviously help those people whose locomotion is affected. People with impaired hearing might need either tactile or visual advice from the IPD.

6.4.5 Visually Impaired

There are currently approximately 3700 guide dogs in the United Kingdom. These may increase the level of confidence for some visually impaired pedestrians, however there are still a large proportion who do not have this aid.

Advice concerning how a blind person should go about crossing the road suggests that they should wait at the edge of the pavement, facing squarely across the road until it is safe to cross (British Broadcasting Corporation, 1986). Rutberg (1976) writes that the urban environment produces internal and external pressures that cause immense stress to the blind person attempting independent travel. Examples she quotes are the transience of everyday life in which fixtures move, and the fear of disorientation which arises through the unpredictability of events occurring during a journey. Beggs (1991) suggests that the slower walking speed of the visually impaired is due to these kinds of stress rather than impoverished visual information or control of locomotion.

Clarke-Carter et al (1986a) suggest that the lack of preview experienced by the visually impaired person affects confidence in their ability to cope with the road environment and causes a slower walking speed. This is mainly because unless they travel slowly the visually impaired person does not have sufficient warning of any obstacles in their pathway to enable them to take avoiding action. He found that the sonic pathfinder device that increased preview by giving its user aural information about obstacles in their pathway, had the effect of increasing walking speed. Only users of guide dogs reach their optimum efficiency (Clarke-Carter et al., 1986b).

Processing load caused by such things as selectively attending to single sources of information and maintaining a memory store of the number of turns made, is a major source of limitation for the blind person. Preview can help reduce this extra load. However, it is argued that devices offering preview should not attempt to present a complete, complex view as this would increase processing loads to an unmanageable level. Decision making demands should be reduced to a minimum (Shingledecker, 1978).

Apart from avoiding obstacles the visually impaired may have the problem of veering from their path. Guth et al (1989) showed that traffic sound cannot be used to guarantee accurate alignment, and there are many implications of veering (Guth and La Duke, 1994). Use of a device for travelling in the urban environment would therefore need to be sensitive to veering (Dodds et al., 1983). Analysing the complex skill of mobility will provide the information required for the design of mobility aids.

The foregoing suggests that the demands on and IPD made by a visually impaired person could be different to those of a sighted person. For example, an IPD would advise its user if the road was safe to cross, but it may not provide information about the presence of stationary cars that are an obstacle between the user and the other side of the road, or give information about the orientation of crossing. In this way, it cannot replace other aids e.g. the long cane which can detect static obstacles. However, it may increase confidence and reduce the stress caused by the fear of having an accident. The fact that guide-dog users can travel with confidence and efficiency suggests that visually restricted pedestrians could benefit from other safety aids.

Finally, it appears that careful consideration of the use of an IPD for the visually impaired should be made to ensure that it does not cause a processing overload. The balance between increased confidence and overload in processing may be different for each individual.

CHAPTER 7 INTERACTION BETWEEN ROAD USERS

CHAPTER 7 INTERACTION BETWEEN ROAD USERS

7.0 INTRODUCTION

In this chapter the nature of pedestrian interactions, both with each other and with drivers, is outlined. Also, the implications of these interactions for the design and use of an IPD are discussed.

In the first section pedestrian to pedestrian interactions are investigated. As a pedestrian, observing other pedestrians will affect what we believe to be acceptable behaviours in the road environment. Classic social psychology studies have shown us the power of norms in our society. However, innovations like the IPD can have an impact on existing norms, and the range of expected behaviours gradually changes over time anyway. Problems may arise if the changes take place too quickly as some people are 'left behind'. Some of these problems and possible solutions are discussed.

The second section investigates driver and pedestrian interactions and how they might affect IPD design and use. 'Pedestrian and driver interactions can be viewed along a continuum from successful co-operative encounters through competitive challenge to near misses and finally accidents.' (Chapman, Wade and Foot, 1982). In order to signal intention, drivers and pedestrians often rely on cues from each other when they cross paths. The pattern of these cues may change with IPD use.

In the final section the unacceptable face of driver-pedestrian interactions is investigated: accidents and near misses. When drivers and pedestrians misread each other's intentions or overlook each other, accidents can occur. Users of in-car devices and the portable IPD would not need to assess intentions. However, not all road users may have access to these technologies, and this could cause some confusion.

7.1 PEDESTRIAN TO PEDESTRIAN INTERACTIONS

When negotiating the road environment, pedestrians most often interact with each other using non verbal communication. For example, Rawdon and Willis (1993) showed that spatial displacement, that is displacing another pedestrian from their pathway, follows set patterns, with women most often displacing men, large groups displacing small groups and handicapped people displacing non-handicapped people. Goffman (1971) reports a number of social conventions that operate in the pedestrian environment, which point to there being tacit understanding between pedestrians. He notes that 'City streets, even in times that defame them, provide a setting where mutual trust is routinely displayed between strangers.' We communicate our intentions to each others and avoid confusions and collisions (Foot, 1984). It can be argued that this non-verbal communication shows an underlying cohesion between pedestrians.

A study on 'Risk and safety on the road' (Carthy et al, 1993) likened the road environment to a jungle in which people's behaviour depends in part on their place in the hierarchy of importance. Using this analogy pedestrians, like some other animals lower down the pecking order, may be operating a 'safety in numbers' rationale (Harrell, 1991b) in which they will cross the road with others, or herd together, to improve their status and level of safety.

Observational work by Wagner (1981) supports the idea that pedestrians copy each other. The study showed that 'backfield' pedestrians waiting to cross at a crosswalk will trust anonymous others in the 'front line' by following them across the road without checking the traffic themselves. Wagner concluded from his observations that 'trust between anonymous others is commonplace in the street corner with respect to avoiding the dangers of moving vehicles'. Foot (1984) quotes an observational study by Lewis in 1981 that showed that children crossing the road in groups often relinquish their personal responsibility to the member of the group closest to the oncoming traffic. Harrell (1991b) has explained this phenomenon in terms of diffusion of responsibility. If this explanation is correct then it may provide further evidence for the hypothesis suggested in the chapter 3 that pedestrians will relinquish responsibility for choosing a safe passage across the road to an IPD.

Studies have shown that 'bad' and 'good' role models of pedestrian crossing behaviour are often copied (Lefkowitz et al, 1973. Mullen et al, 1990). Other variables such as role model's perceived status and crowd size are also important. IPD users should be good role models because they will never choose a dangerous moment to cross. However, problems caused by non-users copying users' behaviour could occur. The pattern of IPD users' non-verbal communications could alter and provide opportunities for misinterpretation and confusion. For example, IPD users may become more confident about crossing roads in an ad hoc way, increase the number of their crossings and act as models for some non-users. Increasing crossing exposure for non-users, especially if it not at a pedestrian crossing facility, is likely to increase accident rates.

Possible problems are likely to be experienced most seriously when the IPD is first introduced. Education for all about the nature and functions of an IPD would facilitate integration of knowledge about the IPD. In particular, it might be important to educate the young pedestrian that portable IPD users' behaviour may be different from non users' behaviour. Making portable IPDs perceptible to non-users may also help prevent misunderstandings.

7.2 DRIVER AND PEDESTRIAN INTERACTIONS

Several studies have illustrated the dynamic of the driver and pedestrian interaction. Goffman (1971) writes that in driving and walking individuals pointedly use all-over 'body gesture',comprising 'intentional displays' of direction, rate and resoluteness of proposed course. More overt examples include pedestrians 'freezing' when they come in contact with a cyclist, to signal that it is the cyclist who must make the decision on how to avoid a collision, and a driver not allowing a pedestrian to catch his or her eye in order to keep the pedestrian uncertain about his or her present status.

Foot (1984) states that there is 'a wider system of informal understanding (which) is concerned with rules of procedure and convention that structure(s) interactions between people'. Also Zuercher's (1976) study found that the personal characteristics of pedestrians and drivers can influence yielding at zebra crossings, and that yielding depends on the number of pedestrians crossing and whether they look at the driver.

Other research has found that the most important explanatory variables for vehicles stopping to let pedestrians cross are pedestrian distance from the kerb, city size, number of pedestrians crossing, vehicle speed and vehicle platoon size (Himanen and Kulmala, 1988). Katz et al (1975) found that drivers stopped and slowed more for pedestrians when their approach speed was low. Harrell and Bereska (1992b) found that yielding for pedestrians was influenced by the recently incurred cost of traffic delay. And recent studies have found that drivers are more likely to stop for pedestrians dressed in bright clothes (Harrell, 1994a), assertive pedestrians who enter the crosswalk (Harrell, 1993), and blind pedestrians (Harrell, 1994b). The above studies illustrate some of the influences that can affect the way drivers and pedestrians interact. The participants are often unconscious of these influences.

Existing pedestrian aids can also influence the driver and pedestrian interaction. For example, Pye (1983) showed that by adding an overlap period(between driver and pedestrian precedence) at pelican crossings, drivers were less liable to harass pedestrians by e.g.'revving up' and 'edging forward'. Polus (1985) found that increasing the level of traffic control by introducing yield and stop signs at intersections caused more vehicle accidents but fewer pedestrian accidents. Another study (Van Houten and Malenfant, 1992) found that introducing a sign 50 feet before crosswalks increased the distance before the crosswalk that motorists yielded, and decreased motor vehicle-pedestrian conflicts. These studies suggest that patterns of interaction can be changed by relatively small changes in the road environment. IPD use might also provoke changes. For example, if IPD users are seen making more crossings, drivers could become distracted.

Research by Rothe (1989) investigated drivers' and pedestrians' perceptions of each other. Pedestrians were found to perceive the road with only peripheral attention and to have clear expectations about motorists' movements. In contrast, drivers thought pedestrians were morally responsible for crossing legally and they expected pedestrians to concentrate on crossing streets and communicate their intentions. IPD users may not communicate their intentions. For example, they may not make head movements prior to crossing. If pedestrians do not communicate their intention to cross before crossing, drivers may not be sure what the pedestrian is planning to do. This should not put the IPD user in any greater risk, but it may confuse the driver.

Brown (1980) argues that in particular, the behaviours of young drivers and child pedestrians are incompatible. Later research (Egberink et al., 1986) confirms that younger drivers detect children less frequently than older drivers. Specifically, Brown suggests that research be directed towards investigating the 'cues drivers use, or need, in order to identify individuals about to cross their path'. If IPD users are not giving these cues then it may be more difficult for drivers to learn and detect non-user cues.

7.3 ACCIDENTS AND NEAR MISSES

Foot (1984) states accident avoidance is highly dependent on our understanding of other people's intentions. He quotes Sheehy (1982 in Foot, 1984) who said 'the road user's perception of danger and hazard is based on a complex interpretation of the actions of other road users and accidents frequently occur as a consequence of an incorrect attribution of plans and intentions to competing road users'. Research on interactions between child pedestrians and drivers shows that drivers are inadequately prepared to cope with children's unpredictable behaviour (Thompson et al., 1985).

Other research has shown that it is the child pedestrian in the driver-pedestrian interaction who takes responsibility for avoiding a potential accident (Howarth and Lightburn, 1980) and it is drivers that misperceive children (Stewart et al, 1993). An IPD would not change this, but the better information available to pedestrians would help them avoid accidents.

Researchers (e.g.. Howarth, 1988; Koenig and Wu, 1994; Van Houten et al, 1985; Wilde, 1980) have suggested ways of changing drivers' attitudes and behaviours towards pedestrians in order to reduce accidents e.g. greater enforcement and driver education. However, pedestrian accidents are still a serious problem, mainly due to human error.

Widespread use of portable IPDs and in-car collision avoidance will relieve both drivers and pedestrians of much of their present task: interactions will become less frequent and more physically remote. Unfortunately, it will take a considerable time for everyone to be equipped and the process of change will itself involve changing attitudes and behaviours towards the technology.

CHAPTER 8 OBSERVATIONAL STUDY METHOD

CHAPTER 8 OBSERVATIONAL STUDY METHOD

8.0 AIMS

Road crossing behaviour was studied in an attempt to assess the feasibility of IPDs from a human factors standpoint. There were two main objectives: firstly, to investigate how people might respond to the initial hypothetical modes and models of IPD, and secondly, to help discover the design features that would be required, so that people could use IPDs efficiently. The results from the study would be used to initiate and then develop ideas, and these ideas would contribute towards designs of IPD that accommodated pedestrian behaviour.

The main purpose of an IPD is to enable its user to cross the road safely. It was pointed out in Chapters Six and Seven that crossing the road involves a number of complex behaviours, all of which can have a crucial bearing on whether or not a safe crossing is achieved. However, perhaps the most important aspect of road crossing behaviour with regard to the IPD is the gaps accepted by pedestrians. This is because the user's perception of what is an appropriate minimum gap will colour his response to the device in action, and perhaps could erode or enhance the user's confidence in it. For this reason the study of pedestrian crossing behaviour was designed to look closely at pedestrian gap acceptance.

In particular the following information on gap acceptance was required:

a) the time that pedestrians think they need to cross roads,

b) the time that pedestrians actually need to cross roads,

c) the trajectories that they follow, and

d) the speeds of vehicles that interact with pedestrians.

Many variables explain the above measures. These can be grouped into two distinct categories: environmental variables e.g. the layout of the road, and human variables e.g. the physical abilities of the pedestrian. Attempts to control and measure such variables will be discussed later in this chapter.

8.1 METHOD

The method of investigation used was video observation of pedestrians in their natural setting. Hopkinson and May (1986) report that this method has various merits, including provision of a permanent and accurate record. Although there are a number of problems in using this method e.g. siting equipment (Rennie and Wilson, 1980), it was felt that for the purposes of this study the advantages outweighed the disadvantages. Considering the data to be collected (as listed above), four other types of method could have been selected: interviews, test method, case studies following pedestrians or observation only. These are discussed below.

The first of these was rejected because it could not produce the accurate quantitative information about gap acceptances that it was felt necessary to acquire. However, interviews can produce qualitative information on people's perceptions and this would be valuable in studying the human factors involved in designing an IPD. For this reason the interviews on the perception of IPDs, reported in Chapters 4 and 5 were done. This means that the quantitative data and the qualitative information that were collected on pedestrian behaviour are independent of each other. Collecting it together would have been better but it would have disrupted the procedure, and extended the observation period greatly.

Video observation was selected in preference to using a test method, in which subjects are asked to perform certain behaviours, because it was required to collect data on the natural behaviour of pedestrians. In addition, obtaining valid gap acceptance data using the test method would involve asking subjects to risk crossing roads, which is ethically questionable. Using a test method could have benefits, however. For example, it could ensure that data was obtained for a specific cross-section of the population, and it could reduce the observation period. However, these benefits do not outweigh the advantages of the video observation method for collecting the amount and type of information required.

Case studies, following individual pedestrians and collecting data on their crossing behaviours, could have been done in a number of ways. For example, by selecting at random a pedestrian present at a particular place and following him or her, or by 'shadowing' a subject for a certain period of time. However, these methods are extremely time-consuming, and unless consent is gained, pedestrians find it disturbing to be followed.

The observation only method, that is with no video recording of events, was also rejected because it would be impossible to collect the amount and type of data required for all pedestrians, without the permanent record of events to refer back to. However, there are three main methodological disadvantages to video recording observations. Firstly, the presence of the equipment on site might affect the behaviour of those being observed, secondly the organisation required to set up video recording equipment impedes a method of random selection and observation of pedestrians, and lastly, the area of observation is limited by the scope of the video recorder.

Efforts were made to overcome the first disadvantage by siting the camera as unobtrusively as possible (see section 8.3.2). Concerning the second disadvantage it was decided to collect data at specifically selected types of location (this is discussed further in section 8.2). Hence, an attempt was made to ensure that a range of crossing environments were observed. The final disadvantage did not prevent the use of any site that was selected. An observer was located at the site in order to collect data that would be difficult to discern from video recordings.

8.2 SITE SELECTION

It was planned to use five different sites for observations. It was hoped that this would enable a range of urban pedestrian crossing environments to be sampled, within the resources available. This section describes the selection process. In sub-section one the criteria for site selection are outlined. In the second sub-section an outline of the sites is given. Sub-sections 3 and 4 describe how each of the sites were classified in terms of the criteria which had been set.

8.2.1 Criteria for Site Selection

In order to simplify the measurement and interpretation of the data it was decided to select sites, where possible, with certain disqualifications (listed below). This restricts the scope of the results. However, it was felt more important to concentrate on the behaviour of pedestrians in relatively simple environmental conditions. Unfortunately it was not always possible to exclude all of the factors (see section 8.2.2).

It was hoped to exclude sites if they were:

a) within 50 metres of a junction,

b) near pedestrian crossing facilities,

c) near pedestrian refuges,

d) on dual carriageways,

e) on one-way systems or

f) adjacent to service roads.

Variables to be considered in the selection of sites were as follows:

i) the type of location, i.e. at least one shopping, residential and industrial area,

ii) the pedestrian accident rate,

iii) vehicle approach speeds,

iv) vehicle flows,

v) pedestrian crossing flows and

vi) road widths.

By careful sampling of the sites it was hoped to include a wide range of values for each of these variables in order to ensure that responses to a variety of situations were observed. Type of location and accident rate are discussed further in section 8.2.3. The remaining variables are discussed in section 8.2.4.

In particular, it was hoped to find two sites with high pedestrian accident rates, and a combination of pedestrian crossing and vehicle flows below.

Number of Sites			
		Pedestrian Crossing Flow	
		low	high
Vehicle	low	1	1
Flow	high	1	2

Vehicle and pedestrian crossing flows are critical for the following reasons:

- Congested traffic flows that resulted in vehicles queueing back for long periods of the day would prevent suitable data from being collected. It was more important to ensure that enough data on crossings between moving vehicles were collected. Crossings made in gaps between stationary or slow moving vehicles are less important.
- Low traffic flows may allow pedestrians such large gaps that no useful data would be gained.
- Low pedestrian crossing flows would reduce the data that could be collected in the observation time available.

8.2.2 Outline of Sites Selected

In order to expedite selection the search was confined to the Boroughs of Haringey and Enfield, which together fall within outer London and Middlesex. Nine areas classed as "industrial" were assessed for suitability regarding vehicle and pedestrian crossing flow, and for layout of the road environment. Unfortunately, for various reasons, none was acceptable. The main problem was that the pedestrian crossing and vehicle flows were such that long periods of observation would be required in order to get the necessary amount of data. It was therefore decided to omit this class of site from the study.

Four sites were selected for detailed study: three were in the London Borough of Enfield and one in the London Borough of Haringey. Descriptions of each road, and the chosen sites within them are given below. These descriptions pay particular attention to the criteria for site selection that are outlined in the previous sub-section. The descriptions show that the criteria for site selection were met, except in the case of a) that the site should not be within 50 metres of a juntion. Unfortunately, it was not possible to find suitable sites because the average spacing of minor junctions in London is of the order of 100 metres in the denser parts of the network where high levels of pedestrian activity are observed.

Site 1 Willow Road, Enfield.

This road is purely residential. It runs between the A110 and the A105, which are both main roads that intersect at Enfield Town's main shopping area. Figure 19 shows its location. Because of its position it is frequently used by drivers wishing to avoid the heavily trafficked one-way system at Enfield Town. Although the road is wide, parking is only permitted at night.

A particular stretch 70 metres long between Riversfield Road and Orchard Way was selected for observation, because a number of pedestrians had been observed to cross there. Its width was 14.46 metres. A photograph of this section is also shown in Figure 19. The section of road is within 50 metres of the junction of Riversfield Road and Orchard Way, and has a small cul-de-sac (Green Grass Gardens) within its bounds. In addition, a pedestrian refuge is situated within 50 metres of the Orchard Way section boundary.

Site 2, Lancaster Road.

This road is predominantly made up of shops, with a few terraced houses between them. Even though it is narrow, parking is allowed at all times along one side; it is part of a bus route and it has a steady stream of traffic throughout the day. Figure 20 shows its location.

A section 85 metres long between the junction of Walton Street and Laurel Bank Road was selected, because five of the thirteen pedestrian accidents at that link in three years 1985-1987 occurred in this section. The width of the road is 7.55 metres. A photograph is also shown in figure 20. The section of road was within 50 metres of the above named junctions, and the junction with Woodlands Road. Lynn Street was within the bounds of the section investigated.

Site 3 Station Road, Winchmore Hill, Enfield.

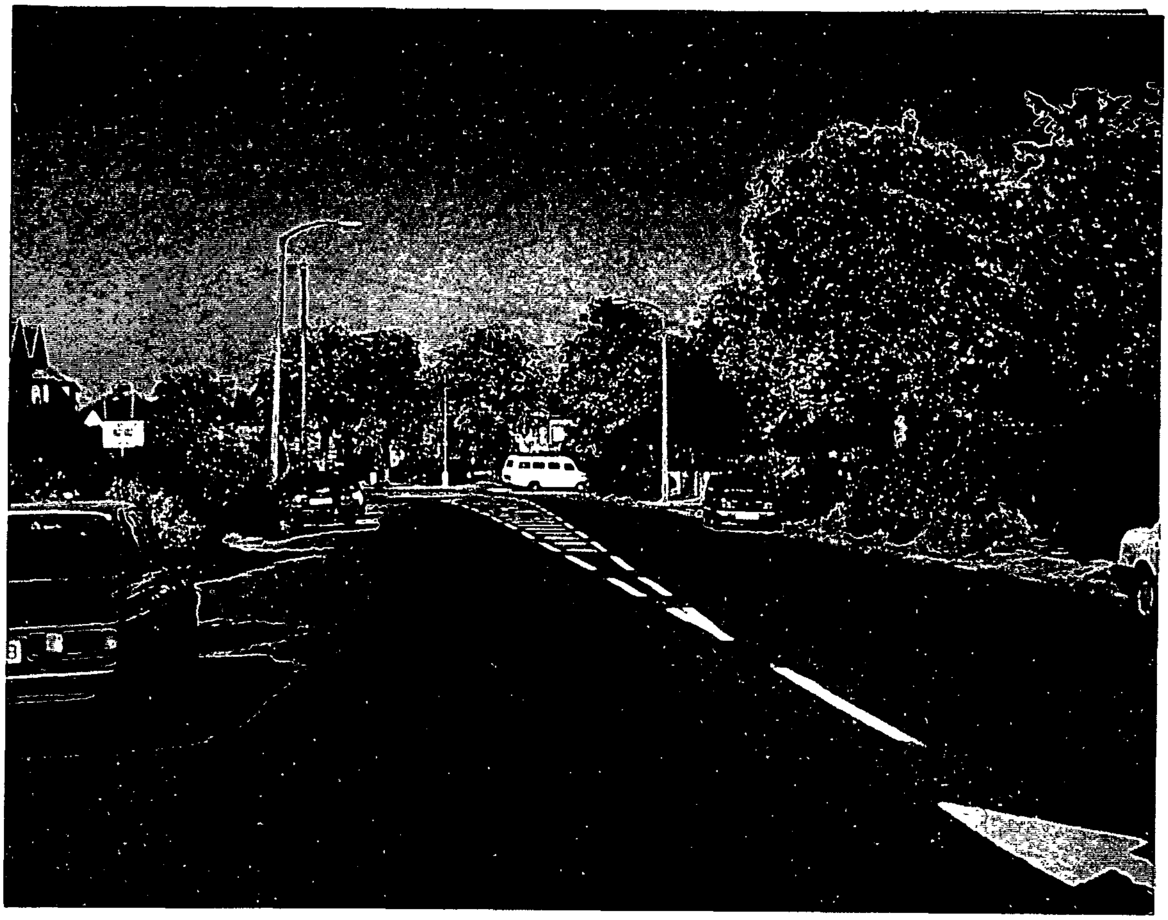
This road is predominantly residential with a few shops near the British Rail Station and a larger collection of shops on the other side of the station surrounding Winchmore Hill Green. Although somewhat narrow, especially approaching the station, vehicles often use this road as a short cut between Southgate and the A105 (Green Lanes) in order to avoid traffic. Parking is allowed in most of the road except near the station. Figure 21 shows its location.

The section of road chosen for observation was between Roseneath Avenue and the station. It was selected because a number of people had been observed to cross there on their way to and from the station. The section was 50 metres long and the road width is 8.00 metres narrowing to 5.96 metres. A photograph of this section is also shown in figure 21. The section was within 50 metres of the junction with Roseneath Avenue and Ringwood Way.

Site 4 High Road, Tottenham, Haringey.

This road is the busiest shopping area in Tottenham. The south part of the road forms the main A10 route between London and Cambridge and the north part is the beginning of the A1010. The north part was selected for observation. Figure 22 above shows its location. The section of interest was between the junctions with Factory Lane and Reform Row, and was 38 metres long. Both of these junctions are within 50 metres of the section boundaries and the junction with Dowsett Road is within the boundaries of the section. This part of the road is 11.92 metres wide, and is at the edge of the shopping area. There are parking restrictions of a single yellow line, although this is often disregarded. This section of road was selected because the vehicle flow is not as high as on the A10 section. Figure 22 also shows a picture of the site.

Figure 19. Location and Photograph of the Willow Road, Enfield Site.



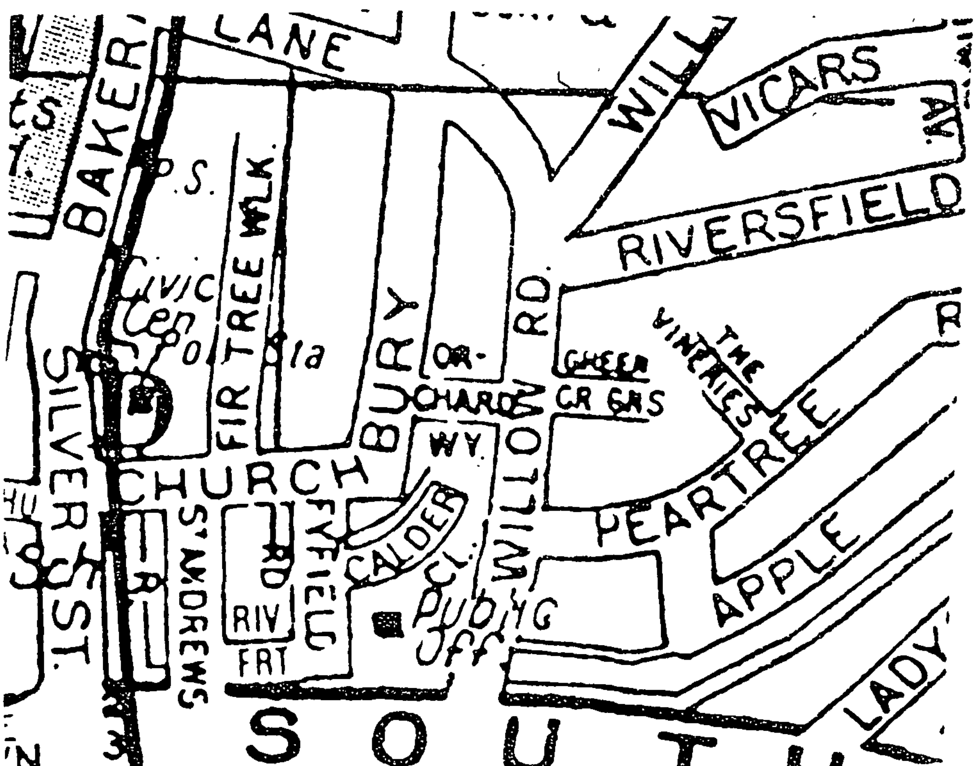


Figure 20. Location and Photograph of the Lancaster Road, Enfield Site.

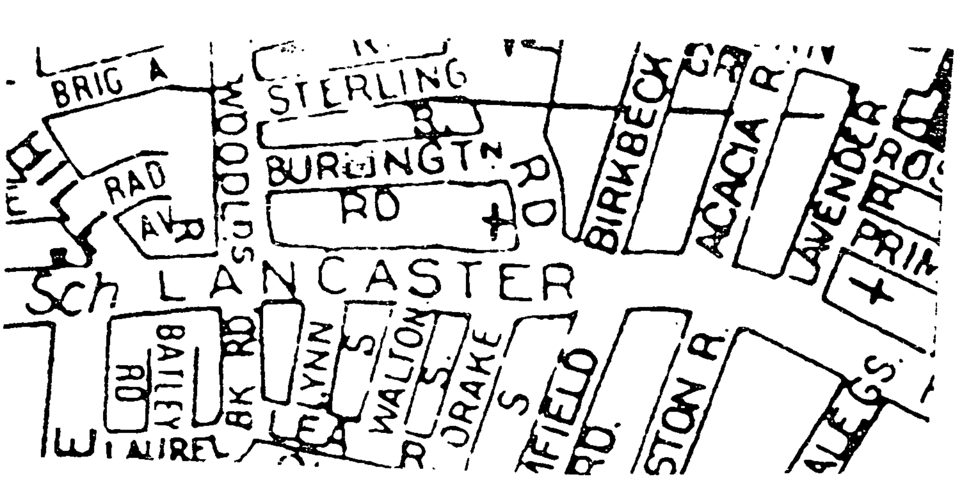
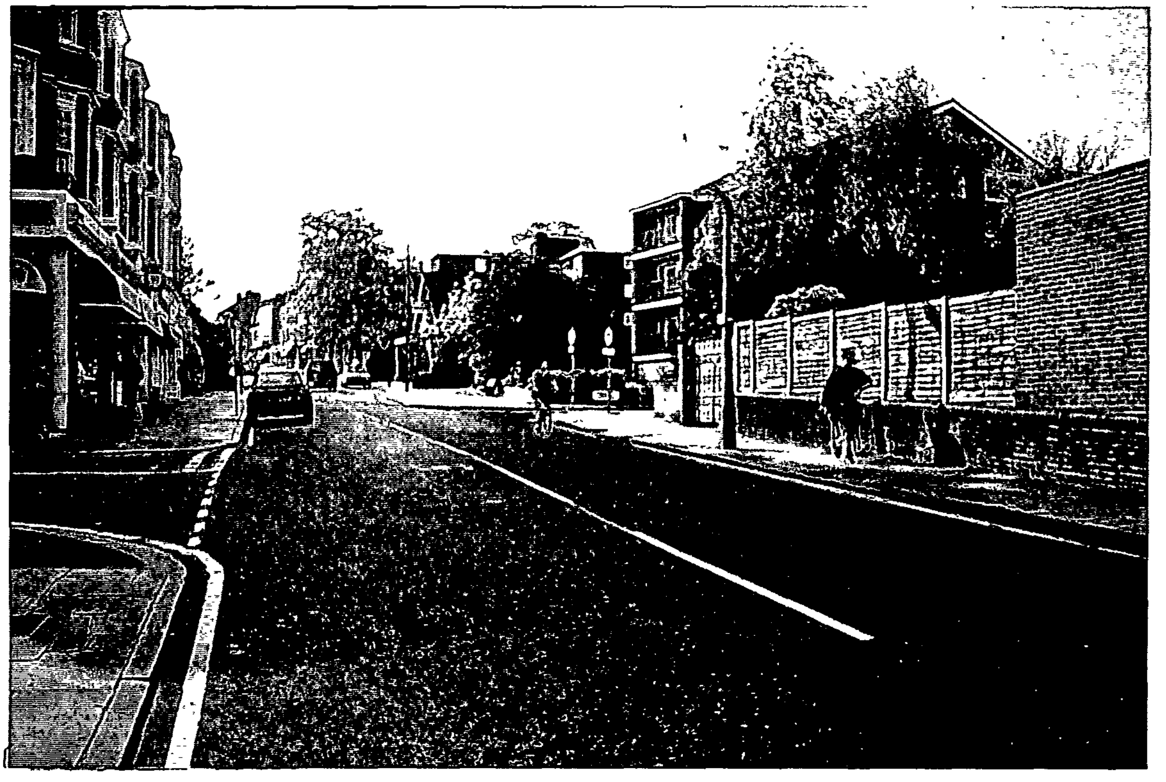


Figure 21. Location and Photograph of the Station Road, Enfield Site.



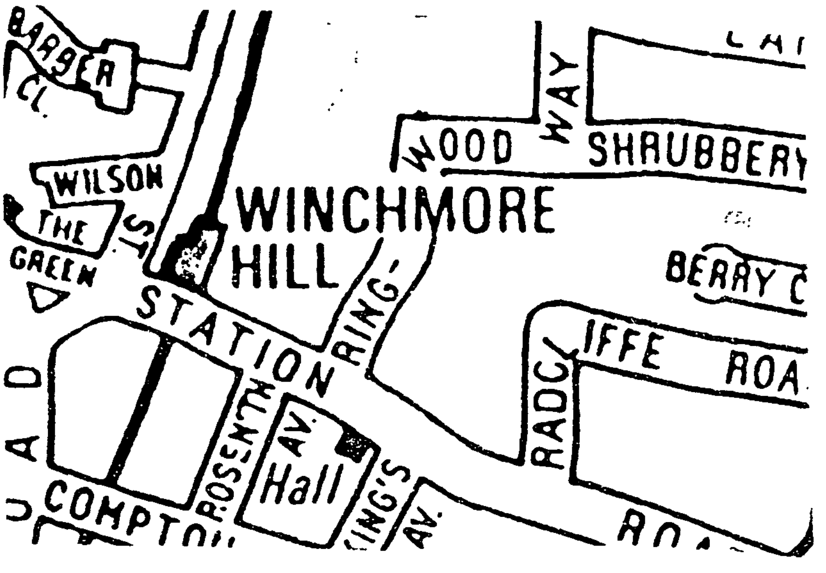
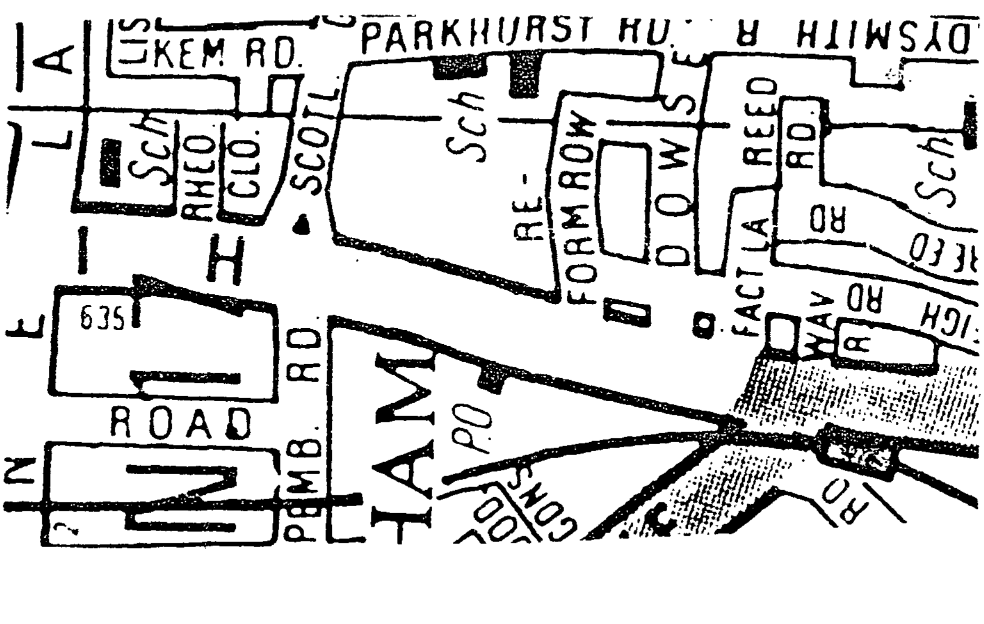


Figure 22. Location and Photograph of the High Road, Tottenham Site.



Finally, the length of the selected sites varied between 38 metres and 85 metres. There were no advantages in keeping the length constant, but there were several advantages in varying it, bearing in mind the limits imposed by video recording. These advantages were that:

- at low pedestrian crossing flow sites more pedestrian crossing movements could be captured in a shorter time period if site length was increased.
- at high pedestrian crossing flow sites, shorter site lengths would allow a better video view of the densely populated site, and hence aid interpretation of the data,
- it did not impose further restraints on selecting sites.

8.2.3 Classification of Sites with Regard to Local Authority Data (LAD)

In this sub-section data for all four sites, which relates to Local Authority variables included in the criteria for site selection (see section 8.2.1 above), are summarised and compared. A summary of how the sites were finally classified on these variables is given.

In order to make an informed selection three sets of information were sought from both Borough Engineer's Departments that appeared to be appropriate: the categorisation of roads, the land use and the pedestrian accident statistics. Each borough has its own system for classifying roads and land use as follows:

Categories of Road.

HARINGEY	**ENFIELD**
1) Trunk Roads	1) Primary Road
2) Designated Roads	2) Secondary Roads
3) Other Borough Secondary Roads	3) Local Distributors
4) Other Non-Secondary Classified Roads	4) Local Access Roads

These classifications have different names but they have very similar definitions. For this reason the systems will be used interchangeably.

Concerning land use, classifications are made per premises, not per road. Hence, to categorise a section of road one must classify each of the premises within it. In both boroughs however, shopping areas are separately identified as such.

Classification of Shopping Areas

HARINGEY	ENFIELD
1) Core Shopping Area	1- 6 point classification
2) Protected Shopping Frontage	system based primarily on
3) Secondary Shopping Frontage	size of shopping area
	1 = largest

In contrast to the classification of roads between boroughs, the classification of shopping areas is not comparable. Haringey's classification is based primarily on the borough planners' perceived importance of the shopping area to the community, whereas Enfield's system is primarily concerned with the size of the shopping area. Table 16 shows the category of road and the shopping area classification for each site.

The boroughs' classification of roads is not intended to imply anything about environmental conditions, merely the importance of the route to vehicular traffic within the overall hierarchy. Hence, the road classification may not be very useful for this research, except in terms of indicating the likely level of vehicular traffic flow. The descriptions of the sites and figures 19 - 22 illustrate the differences between the sites. These are more descriptive of each site's specific characteristics and are likely to have more impact on pedestrians' perceptions than the borough classifications of the site. A reduced flow of traffic does make a difference to pedestrian crossing behaviour, but there are other variables which are equally important. Because of these difficulties it was felt that classifying roads using this system would serve no useful purpose for this research.

Table 16. *Classification of Roads and Shopping Areas at the Four Sites Where Pedestrian Behaviour was Observed.*

Borough/Site	Category of Road 1-4	Shopping Class
ENFIELD		
1) Willow Road	3	n/a
2) Lancaster Road	3	3
3) Station Road	4	3
HARINGEY		
4) High Road, Tot.	1/3	1

Also, the classification of shopping areas may not be a useful way of characterising them from the pedestrian's point of view. For example, the shopping areas at Lancaster Road and Station Roads are both classified as 3, primarily because the number of retail outlets is similar. However, pedestrians at Station Road who use the part of the road observed are less likely to perceive themselves as in a shopping area for three reasons. Firstly, there are only six shops on one side of the road, and they don't attract many customers e.g. insurance agent. Secondly, these shops are set apart from the rest of the small local stores by the railway line and some flats (making a gap of approximately 75 metres between the larger and smaller group of shops). Lastly, most of the people using this site are travelling between the surrounding residential area and the British Rail Station, and did not use the shops.

Taking these facts into consideration Willow Road and Station Road were classified as residential sites, and Lancaster Road and High Road, Tottenham were classified as sites in shopping areas of a local and busier type respectively. It was felt that these definitions bore more relationship to how pedestrians would perceive these sites than the boroughs' classification systems.

The third set of Local Authority data, accident statistics, is classified the same way in each borough. The number of pedestrian accidents over the whole 3 year period 1985-1987 for the four sites was as follows:

Willow Road	0
Lancaster Road	13
Station Road	0
Tottenham High Raod	14

Willow Road and Station Road had zero accidents and compared to other local roads Lancaster Road and High Road, Tottenham had high numbers. Taking into consideration the pedestrian crossing flows collected (see table 18 below) the rate at Lancaster Road was particularly high. Table 17 simplifies and summarises how the four sites selected were classified in terms of the type of road and the pedestrian accident rate.

Table 17. *Summary Information Concerning the Four Sites Where Pedestrian Behaviour was Observed.*

Site	Road Width (in metres)	Pedestrian Accident Rate	Type of Road
Willow Road	14.46	low	residential
Lancaster Road	7.55	high	shopping
Station Road	5.95-8.00	low	residential
High Road, Tot.	11.92	high	shopping

8.2.4 Classification of Sites Based on Pilot Data Collected at the Site

The final features of importance in selecting sites were the vehicle approach speeds and flows and the pedestrian crossing flows. It was hoped to vary these within and between the sites selected. Data on these variables were collected at the four sites on two separate occasions. The following table gives: the vehicle flow per hour, the mean vehicle speeds (in miles per hour calculated from a sample of 40 vehicles at each site) and the pedestrian crossing flow per hour (all including both directions of travel) for the four sites selected. The times of day at which these data were collected are also shown.

Table 18. *Pedestrian Crossing Flows, Vehicle Approach Speeds and Flows (per hour) by the Time of Day that these Measurements were Taken at the Four Sites Observed.*

Site	Time Data Collected	Vehicle Flow p.h. both dir	Mean Veh. Speed m.p.h. (n=40)*	Ped Cross Flow p.h. Both dir
Willow Road	8-9am	1497	23	60
	3-4pm	1134	31	42
Lancaster Road	10-11am	774	24	117
	2-3 pm	738	no data	54
Station Road	8-9am	1104	21	144
	2-3pm	744	24	24
High Road, Tot.	11-12am	984	26	300
	12-1pm	867	24	183

* speeds for 20 cars in each direction per site were obtained.

Concerning vehicle approach speeds, table 18 shows there was not much variation between sites, although there was a difference between 8am and 3pm at the Willow Road site. The width of the road to some extent constrains speed and the level of vehicle flow. For this reason the following formula was used to produce an index of vehicle flow that would allow the sites to be more easily compared.

$$\frac{vf}{rw} = vfi$$

where vf = vehicle flow per hour in both directions

rw = road width

vfi = vehicle flow index

The vehicle flow index can only serve as an approximate guide to conditions at a site because the movement of vehicles can also be affected by many other variables. For example, the presence of parked vehicles would effectively reduce the width of the road available. Table 19 shows the vehicle flow index for the vehicle flows shown in table 18. The width of the road at each site is also given. There are clear differences in the flow index between sites. Also, within each site there is variation between different times of day.

Concerning pedestrian crossing flows, the figures in table 18 above were collected at sites of varying lengths. For this reason the following formula was applied to the figures in order to establish an index of pedestrian crossing flow per unit length of kerb.

$$\frac{pf}{sl} = pfm$$

Where pf = Pedestrian crossing flow

sl = Site length

pfm = Pedestrian crossing flow per metre

Table 19. *Vehicle Flow Index and Pedestrian Crossing Flow Index by the Time of Day and Site Length for Each Site.*

Site	Site length in metres	Time data Collected	Vehicle Flow Index both dir p.h.	Pedestrian Flow Index both dir p.h.
Willow Road	70	8-9am	105	.86
		3-4pm	78	.6
Lancaster Road	85	10-11m	102	1.38
		2-3pm	98	.64
Station Road	50	8-9am	158	2.88
		2-3pm	107	.48
High Road, Tot	38	11-12am	82	7.9
		12-1pm	73	4.81

Table 19 also shows the pedestrian crossing index for the pedestrian crossing flows from Table 18 above. This shows that there was a variation in the level of pedestrian crossing flow both between sites and within sites. However, two of the pedestrian crossing flows shown in the above tables were affected by specific events. The 3pm figure at Willow Road of 42 (0.6 pedestrian crossing flow index) included children coming home from nearby secondary schools. At other non-peak travel times the pedestrian crossing flows were observed to be lower. Conversely, the 2pm figure at Lancaster Road of 54 (0.64 pedestrian crossing flow index) was lower than it was observed to be on most days, because it was taken on an early closing day when no shoppers were about. These observations point to the variability in pedestrian crossing flows and the importance of selecting appropriate times to make video observations. These issues will be discussed further in sub-section 8.3.1.

The pilot data collected at each site were vehicle speeds, vehicle flows and pedestrian flows. These measures varied according to the time of day, the type of site and the characteristics of the site. It was hoped to assess the effect of differing vehicle speeds at different sites on the behaviour of pedestrians. However, it was noted that vehicle speeds did not vary much between or within sites, except at Willow Road where a decrease of vehicle flow had the noticable affect of increasing the vehicle speed. It is hypothesised that this lack of variation was because the speed limit at all of the sites was 30 mph and congestion of one sort or another during the day makes it impossible to reach much higher speeds than this on single carriageway urban roads. Willow Road may have been an exception due to its greater width. It is therefore concluded that the effects of vehicle speeds on pedestrian behaviour can probably only be assessed using data from individual vehicles at all sites.

8.3 PROCEDURE

Video recording is relatively inexpensive; however, data retrieval costs are high. In order to provide some useful information on pedestrian behaviour and gap acceptance it was planned to analyse a total of approximately 1,000 pedestrian crossing movements at the sites. This amount of data would ensure that a range of behaviours were observed.

At each site the camera was mounted at a height of approximately 5 metres, in a position where it was possible to view at least 50 metres of road and footway. Whilst video recording took place, two observers collected information (that it would not be possible to glean from subsequent viewing of the video recordings) on all pedestrian crossing movements.

Observer 1 was situated near the crossing point and collected information on each pedestrian's characteristics and behaviours, for example the age group of pedestrians and whether or not they hesitated prior to crossing. This information was recorded on an audio cassette player.

Table 20. *Method and Type of Data Collected by Two Observers During the Video Recording of Pedestrian Road Crossing Behaviour.*

Observer Number/position	Method of Data Collection	Information Collected
1 near the crossing point	verbal commentary onto tape recorder	pedestrian behaviours/ characteristics
2 at the video recorder	verbal reports onto video sound track	speed of vehicles that interacted with ped's crossing the road at: i) the crossing point ii) a stated distance before the cross point

Observer 2 was situated by the video equipment and collected vehicle speeds with a radar gun. The vehicles of interest were those that interacted with a pedestrian crossing the road. When a pedestrian crossed in front of a vehicle, two measurements of that vehicle's speed were required: one at the place where the pedestrian had crossed and one at 50 metres before the crossing place. This information was recorded onto the sound-track of the video recording. Table 20 above summarises the method and type of data collected by the two observers.

To ease analysis, the audio tape recordings and video recordings were synchronised. Both observers had a two way radio. Using the time displayed on the video recording, Observer 2 counted down a start time for the audio recording. This was received by Observer 1 via the two-way radio and recorded straight onto the audio cassette. The audio tape recordings were dubbed onto the sound-track of the video tape recordings afterwards in the laboratory. This helped analysis because all of the visual and aural information was presented together.

8.3.1 Dates and Times of Video Recordings

Times of day that the video observations took place were carefully selected. Table 21 shows the date, day and times of day. The Willow Road times of 12 noon-6pm were chosen in order to include low pedestrian crossing flows in the afternoon and higher ones during the peak hour between 5pm and 6pm. The shopping areas of Lancaster Road and High Road Tottenham were recorded all day, the former to obtain data on crossing behaviour at a relatively low pedestrian crossing flow site by comparison to the latter site. Also, High Road Tottenham was videoed on a weekday and a Saturday to establish if there was any difference between a normal working day and a weekend day. Station Road was videoed between 7am-10am in order to obtain the higher pedestrian crossing flows caused by commuters making their way from their residences to the British Rail Station.

Table 21. *Date, Day and Time of Day that the Video Observations of Pedestrian Crossing Movements Took Place.*

Site	Date	Day	Time of Day
Willow Road	17-10-1989	Tuesday	12 noon-6pm
Lancaster Road	31-10-1989	Tuesday	9am-5pm
Station Road	1-11-1989	Wednesday	7am-10am
High Road, Tottenham	11-11-1989	Saturday	9am-5pm
	and 13-11-1989	Monday	9am-5pm

8.3.2 Siting of Equipment and Observers at the Sites Selected

To carry out this study the following items were essential:

- cones
- tape measure
- radar speed meter gun

- tape recorder, cassettes and batteries
- two way radios
- video camera recorder, tapes and batteries
- wide angled lens
- tripod
- monitor
- ladder
- mini bus with platform roof

The video camera was a colour JVC, model GX/N7E with stereophonic sound and a telephoto/wide angle zoom lens. Attached to this was a JVC character generator, model CG/C7E. The video cassette recorder was model HR/F10EK. External batteries were used to accomodate the observation periods of up to 8 hours at each site. The hand held radar speed meter was a Tribar Muniquip, model T3 with digital readout. This make and model is used by the police because of its accuracy, which is quoted as + or -0.5%.

In order to be as unobtrusive as possible it was hoped to site all equipment and observers in surrounding buildings. Unfortunately, this was possible only in one case, either because permission could not be obtained or because there was no conveniently situated building. For these reasons at three of the four sites the video equipment was mounted on the platform roof of the mini-bus, which was parked approximately 50 metres away from one of the boundaries of the site. At the remaining site the equipment was placed on the roof of a single storey shop.

The two observers tried to be as inconspicuous as possible by sitting in the mini-bus or standing in an unobtrusive position. Table 22 gives further details concerning the siting of equipment and the position of observers at each site.

Table 22. *The Position of the Equipment and the Two Observers at Each of the Sites.*

Site	Position of Observer 1	Observer 2	Equipment
Willow Road	front garden	in mini-bus	on mini-bus at pavement extension by bend
Lancaster Rd	front garden	in mini-bus	on mini-bus in shop forecourt
Station Road	public bench	in mini-bus	on mini-bus at kerbside
High Rd Tott.	alleyway	on roof of ground floor shop	

8.3.3 Data to be Collected

It was planned to collect several types of data on all of the crossing movements that occurred within consecutive time segments of the video recordings. All movements were collected within each time segment to ensure that the range of pedestrian behaviour was observed and there was no bias in the sampling. A summary of the data that was collected and the time segments used is in section 9.1.1.

A list of all the data collected from the video observations together with their definitions is given in Appendix 27. The 37 items of data that it was intended to collect for each individual crossing movement can be put into six groups as listed below. The following explains each group and the importance of each category of measurement.

1) This included basic information that could be gleaned from the video recording about

the environment, circumstances and behaviour of each pedestrian who crossed the road and the vehicles that they interacted with, if any. It was hoped to explain crossing behaviours like moving into the road or along the kerb by some of the other categories of measurement taken. For example, pedestrian visibility, pedestrians with push-chairs or the type of vehicle approaching might affect gap acceptance and delay.

2) a. Traffic flow when the pedestrian crossed. The flow of traffic may affect pedestrian crossing behaviour.

b. Pedestrian flows on the footway when the pedestrian crossed. The general presence of pedestrians may increase their status, and hence affect crossing behaviour.

c. Pedestrian crossing flows when the pedestrian crossed. These may also affect pedestrians' confidence and crossing behaviour.

3) Information that had been collected at the time of video observation about the characteristics of each pedestrian who crossed the road. Collecting general characteristics like age, sex and disability of pedestrians would allow investigation of their affects on pedestrian crossing times and delays.

4) Data, also collected at the time of video observation, on the angle of crossings both sides or legs of the road. This is also important in understanding gap acceptance and delay.

5) Information that had been collected at the time of video observation about cars that had interacted with pedestrians who had crossed the road. Assessing the affect of pedestrians' crossing on motorists' speed is also important in understanding gap acceptance and delay.

6) a. Each pedestrians' crossing and wait times. It was hoped to explain these data by some of the other observations.

b. Accepted gaps or lags (measured in time) between arrivals of cars at each pedestrian's crossing point, for the first leg of the crossing i.e. the first half of the road crossed. Again, it was hoped to explain these data by some of the other observations.

c. As in b. above but for the second leg of the crossing.

The first five of the six categories of data listed above were collected by watching and listening to the video recordings. The last category, involved the measurement of time intervals between the beginning and end of behaviours recorded on the video.

8.4 RETRIEVING AND INTERPRETING THE DATA.

Several of the measures involved some degree of judgement by the site observers or the video data retriever. There were three aspects of the data which are worthy of mention regarding data retrieval or interpretation : pedestrian age group, selection and location of vehicles, and pedestrian cross, wait and gap acceptance timings. These are discussed in the following three sections.

8.4.1 Pedestrian Age Group

Estimating the age group of pedestrians was done by observer one on site. To aid accurate judgement several practice sessions were held. In these, observer one selected a pedestrian up to fifteen yards away and estimated his or her age group. When the pedestrian reached observer one's position, he or she was asked to indicate his or her true age group. During these practice sessions the number of accurate estimates increased from 70% to 80%.

Analysis of the final practice session showed that 80% of the pedestrians in the sample were in the middle age range group(aged 15-59). Also, all of the incorrect estimates fell into this age group. It was decided to limit the age categories to three: 0-14, 15-59 and 60+ as this is consistent with the child, adult and elderly categories used in the interviews. Errors in categorisation are most likely to have occurred at the boundaries of each group. Hence, they will not affect many observations.

8.4.2 Selecting and Locating Vehicles

The second aspect of the data collected which involved some degree of judgement was the selection and location of vehicles. The vehicles of interest were those that interacted with a pedestrian crossing the road. When a pedestrian crossed in front of a vehicle, two measurements of that vehicle's speed were required: one at the place where the pedestrian had crossed and one at 50 metres before the crossing place.

The speeds were easily collected by means of a radar gun but selecting the correct vehicle quickly enough, 50 metres before the crossing place, was a more difficult task. For this reason several practice trials were done by observer 2. After five one-hour sessions observer 2 was able to select the appropriate vehicle on most occasions. However a number of difficulties in doing this did emerge. For example, when pedestrians crossed in quick succession or unexpectedly, insufficient time was available to select the correct vehicle.

8.4.3 Pedestrian Cross, Wait and Gap Acceptance Times

The final aspect of the data that involved some interpretation was the pedestrian cross, wait and gap acceptance times. These were obtained from the video recordings. This involved the measurement of time intervals (in seconds and tenths of a second) by pressing the pause button on the video recorder at the start and end of the event to be measured. Two types of inaccuracy may have occurred in retrieving these data: firstly, in deciding when the various actions to be registered began and ceased, and secondly in the reaction time of the person retrieving the data by pressing the pause button.

In the former case specific criteria were adopted to aid accurate judgement. For example, an 'accepted gap or lag' in the traffic was defined as the time between the pedestrian starting to cross and the front bumper of the vehicle that the pedestrian was crossing in front of reaching the pedestrian's crossing path. Appendix 27 lists the definitions of each of these data. These definitions characterised the given behaviours but in some cases a degree of interpretation was still required in deciding when these characterising behaviours had actually occurred. Practice sessions aided these judgement skills. In addition, reliability was briefly assessed by double-checking some of the judgements made. These were nearly always consistent.

Concerning inaccuracies caused by the key press reaction time of the person retrieving the data, practice sessions followed by trials to test accuracy resulted in reaction time being reduced to less than .3 of a second. To measure the duration of a particular behaviour, a key was pressed at the beginning and the end of the behaviour. Therefore, if there was a .3

reaction time registering the beginning of the behaviour and a .3 reaction time registering the end of the behaviour, the measurement of the behaviour itself would be correct. In the worst case, there would be a .3s reaction time at one of the key presses and virtually no reaction time on the other. This would result in a maximum -.3s error in the measurement of the behaviour.

Due to time constraints and resource limitations this data retrieval was more rudimentary than would have been preferred. However, it was felt that the quality of data was acceptable.

8.5 CONCLUDING COMMENTS ON THE METHODOLOGY

Given the amount and the type of data which it was important to collect, video observation of pedestrians in their natural setting was judged to be the most efficient method. All other methods, discussed in section 8.1, had disadvantages of one sort or another that made them unsuitable alternatives.

The main advantages of using the video observation method were that it allowed maximum data collection in the time available; ethical problems were kept to a minimum, and pedestrians' natural behaviour was observed. There were methodological disadvantages but fortunately most of these were resolved by careful planning of the observations.

The sites used were not representative of the total population of sites, and it is therefore possible that the results are not representative of all pedestrian behaviours. The limited scale of this study did not permit a truly representative sample. However, the sites used did enable important data on pedestrian gap acceptance to be collected which could supply useful information about pedestrian behaviour.

Also, this method does not relate individual pedestrians' behaviour to the wider context of their lives and situations. Knowing this would be useful, but it is beyond the scope of this study. Some qualitative information on pedestrians' overall perceptions was collected (see chapter 5), in the hope that it would form the basis of a wider understanding of behaviour patterns. The following chapter outlines the results of the observational study.

CHAPTER 9. RESULTS, DISCUSSION AND CONCLUSIONS OF THE OBSERVATIONAL STUDY

CHAPTER 9. RESULTS, DISCUSSION AND CONCLUSIONS OF THE OBSERVATIONAL STUDY

9.0 INTRODUCTION

In order to discover what an IPD must be capable of doing, it is useful to know how humans successfully achieve the same task. This chapter reports the results of the observational study of pedestrian behaviour and discusses the implications for IPD design and use.

The study concentrated on pedestrian gap acceptance. Environmental and human variables were collected to find out if they could help explain pedestrian gap acceptance. Specifically, (1) the time people think they need and (2) the time they actually need to cross the road (3) crossing trajectories and the speed of vehicles that interact with pedestrians were collected.

One site was observed on two different occasions, a Saturday and a Monday, and the data is reported separately. Section 8.2.2 detailed the sites selected and section 8.3.1 gave the dates and times that observations took place, but for convenience, information about how the data is broken down is listed below.

1 Tottenham High Road - Saturday
2 Tottenham High Road - Weekday
3 Station Road - Weekday
4 Willow Road - Weekday
5 Lancaster Road - Weekday.

In this chapter, section 1 outlines how much data was collected and discusses basic information about the pedestrians that were observed and their environment; Section 2 deals with pedestrian delay; section 3 describes the angles of crossing from the perpendicular used when crossing the road; section 4 summarises data on pedestrian speeds and crossing times; section 5 reports the speeds of vehicles that interacted with pedestrians crossing the road; section 6 attempts to explain pedestrians' gap acceptance, and section 7 outlines the implications of the results for the IPD. In section 8 the difficulties encountered in using the observational method and analysing the resulting data are outlined. Finally, section 9 reviews the results.

9.1 BASIC OBSERVATIONS

This section outlines basic observations about the pedestrians and their environment, it includes a summary of the data that was collected, the age, sex and disability characteristics of the sample, details of environmental variables and other characteristics of the pedestrians.

9.1.1 Summary of the Data Collected

Appendix 28 gives a summary of the data that was collected at each site. Altogether data on 906 pedestrian crossing movements at four sites was collected, covering a total period of 11 hours and 45 minutes. However, not all the observations included the full range of variables. Only 240 of the crossing movements included data on the speed of vehicles. Just 694 observations included both crossing and wait times together with gaps/lags accepted. For many of them, a) some parts of the total crossing and/or wait times are not available because of obscured view, and b) one or both of the gaps/lags accepted are not available because the pedestrian waited in the road before crossing, there was no vehicle, or the vehicle was stationary or obscured. Details of the data to be collected for each pedestrian crossing movement are given in Appendix 27 and a summary and discussion of these data is made in section 8.3.3.

9.1.2 Age, Sex and Disability of the Sample

Table 23 gives the breakdown of age and sex of the pedestrians observed. Note that age group 1 refers to children not holding an adult's hand. Children holding an adult's hand were not included in the data.

Table 23. *Number and Percentage of the Total Number of Pedestrians Observed by Sex and Age.*

	Number of Subjects			
Age Group	Female	Male	Total	%
1 0-14	31	28	59	6.8
2 15-59	349	361	710	81.6
3 60+	58	43	101	11.6
Total	438	432	87	
%	50.3	49.7		100.0

This shows that overall, approximately equal numbers of men and women were observed, and the majority fell into the middle age group. The proportions varied somewhat from site to site: with many more elderly people (25%) and more women (60.%) at the Lancaster Road site. There were no children at the Station Road Site and only 4 at Tottenham High Road.

A record of observable disability was taken in all of the 906 observations. There were only 6 disabled pedestrians (0.7%). Five of these were recorded at the Lancaster Road site. The low number of observations makes further analysis of disabled pedestrians impractical.

9.1.3 The Environment

Seven variables were chosen to characterise the pedestrian's environment while crossing. Each of them are defined in Appendix 27.

1. visibility
2. weather
3. direction of crossing
4. type of vehicles that each pedestrian interacted with
5. vehicle flow
6. pedestrian flow

7. pedestrian crossing flows

1. Overall figures for pedestrian visibility at crossing were as follows:

	Observations	%
1 = good	566	62.5
2 = fair	320	35.3
3 = bad	20	2.2

Most people had good visibility for crossing, but there was a substantial minority who did not, with a small number (2.2%) having bad visibility.

Almost all of the bad visibility occurred at Lancaster Road (18 of the 20 observations), and was caused by parked, queuing and delivery vehicles. Pedestrians were not deterred in their choice of crossing place by parked cars, in fact, observations showed that they often seemed to use them as shields when waiting to cross. Visibility conditions at Station Road and Willow Road were good.

2. There were dry clear weather conditions at all sites except Tottenham High Road on Monday when there was a light fog. This did not affect the categorisation of visibility.

3. Analysis of the direction of crossings made showed that at Tottenham High Road, Station Road and Willow Road one direction was used more often than the other. This reflected local conditions at the time of day, which were as follows:

-Tottenham High Road - travel to the Post Office.

-Station Road - commuters travelling to the B.R. station.

-Willow Road - children and shoppers travelling home.

-Lancaster Road - travel from one shop to another on opposite sides of the road.

For both directions, crossings occurred more often at certain places, as though there was a general consensus where the optimum places were. Parked vehicles and local attractions and layouts may have played a role. For example, Willow Road had a grass border between the footway and kerb, which directed people wanting to cross the road to the small paved areas which joined them (see figure 19).

4. Vehicles that interacted with pedestrians crossing the road were classified into four groups: two wheelers, cars, vans, lorries or buses. Table 24 shows the number of observations in each group and percentages for both legs of the crossing combined.

Table 24. *Type of Vehicle Interacting with Pedestrians Crossing the Road.*

	Number	%
Two Wheeler	23	1.6
Car	1128	78.1
Van	196	13.6
Lorry/Bus	97	6.7
Total	1444	100.00

These figures were similar across sites, except there were more lorries and buses at the Totteham High Road site and less at the Station Road and Willow Road Sites. This was expected as Tottenham High Road is a main road; Station Road and Willow Road are residential areas.

5. Vehicle flows for both directions, pedestrian pavement flows for both sides of the road and pedestrian crossing flows in both directions were recorded at five minute intervals. Appendix 29 reports the minimum and maximum flows (in five minute intervals), including both directions, for each site and day. Also given are the mean flows per hour, taking account of both directions, for each site and day. Section 8.2.4 discussed using a Vehicle Flow Index (VFI) which takes into consideration the varying widths of the roads used, and

a Pedestrian Flow Index (PFI) that takes into account the length of the site used in the observations of pedestrians crossing. The VFIs and the PFIs per hour for each site and day are also given.

These figures are similar to those reported in the pilot observations (section 8.2.4, tables 18 and 19). In summary, there was a range of flows at each site during the observation period. When road width is taken into consideration the VFIs show that there was a considerable difference in vehicle flow between sites. Vehicle flow was higher at Tottenham High Road on Saturday than it was on Monday.

6. There was also a considerable range in pedestrian flow, with Tottenham High Road accommodating at least three times as many pedestrians on the footway as any of the other sites.

7. In terms of pedestrians crossing the road, Tottenham High Road had the highest flow, with Saturday's flow being almost double that of Monday's.

9.1.4 Characteristics of the Pedestrians

In this sub-section the following pedestrian characteristics are described:

1. accompanied
2. holding a child's hand
3. with a pushchair or pram
4. carrying unusual amounts of baggage/leading a dog.

The number in each category and the percentages are shown in table 25.

Table 25. *Characteristics of the Pedestrians.* N = 906

	Number of Pedestrians and %				
	No	%	Yes	%	Total
Accompanied	150	16.6	756	83.4	906
Holding child's hand	17	1.9	889	98.1	906
Pram/pushchair	36	3.9	870	96.1	906
Heavy bag/dog	26	2.9	880	97.1	906

16% of people were accompanied and the percentages varied from site to site. The other three attributes were not so commonly observed, but here again there appeared to be some variation between sites. Combining these three variable together, 9% of pedestrians can be described as 'encumbered' and would probably have experienced greater than average difficulty in crossing the road (see section 9.4 for further discussion of this).

In each of the following five sections (9.2 - 9.6) summary data for the whole sample is given first, and following this various ex post facto research hypotheses, formulated from the initial analyses of the data, are tested.

9.2 PEDESTRIAN DELAY

Pedestrian delay and strategies to avoid delay were measured by several different variables:

1. waiting in the road
2. moving along the kerb or road whilst waiting to cross
3. moving along the centre line
4. forcing a crossing on the first and second leg
5. time delays incurred a) on the kerb/gutter, b) at midway

Table 26 show the number of observations in each of the first four categories listed above; percentages are also shown.

Table 26. *Pedestrian Delay Variables: Number of Observations and Percentages.*

N = 906

	Number of Pedestrians and %				
	No	%	Yes	%	Total
Moves into road	260	28.7	646	71.3	906
Moves along kerb/rd	118	13.0	788	87.0	906
Moves along centre line	8	.9	898	99.1	906
Forced X leg 1	15	1.7	891	98.3	906
Forced X leg 2	30	3.3	876	96.7	906

1. More than a quarter (29%) of pedestrians moved into the road before crossing, especially at the wider Tottenham High Road and Willow Road, and at Lancaster Road where parked cars often protected pedestrians waiting to cross. Conversely, only 28 (12%) of the 238 pedestrians observed at the narrower Station Road waited in the road. Stepping into the road may illustrate people's attempts to reduce the crossing time and gap they require to cross the road.

A Chi-squared test was done to test the null hypothesis:

> Pedestrians' level of visibility will not significantly affect whether or not they step into the road before crossing.

The result was significant and the null hypothesis was rejected (N = 906, Chi-squared = 99.150, p = < 0.00005). Worse visibility, most often caused by parked and queuing cars, encouraged pedestrians to move into the road, presumably to see better.

2. A smaller but significant percentage (13.%) walked along the kerb or road whilst waiting to cross. This occurred less frequently at Lancaster Road because of the parked cars and more frequently at Station Road when pedestrians were late for the train.

3. Moving along the centre line did not occur very frequently (0.9%), and only at the wider Tottenham High Road and Willow Road sites. This behaviour suggests pedestrians have reduced delay by making a two stage crossing, or perhaps they got caught halfway. None of the sites had a cental refuge.

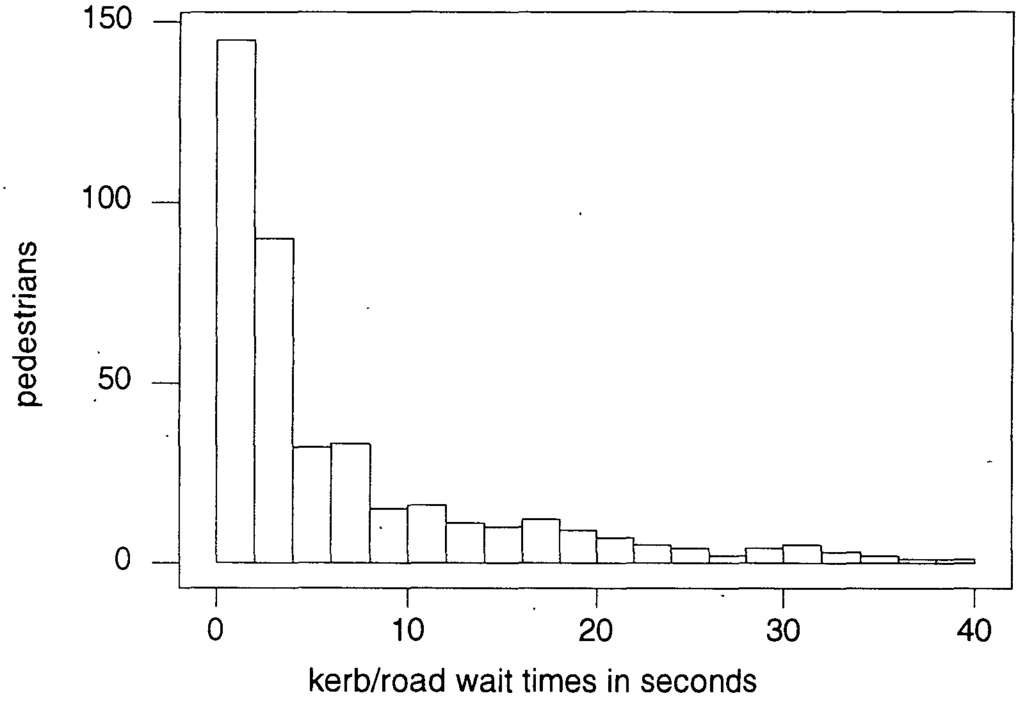
4. Forced crossings are of special interest because they are the strongest impatience indicators. Table 26 shows that they did not occur very often on the first leg (1.7%) or the second leg (3.3%). Combining the data, a forced crossing occurred in 5.1% of crossings. Most of these (35 of 45) occurred at the Lancaster Road site where long pedestrian delays and periods of slow moving traffic may have encouraged assertive behaviour. Similar conditions prevailed at Tottenham High Road, but less forced crossings occurred there because one side of the road was often queued back and pedestrians were able to pass between stationary vehicles.

Although the figures are too small for statistical analyses there was no evidence that one age or sex grouping was more often responsible for making forced crossings than any other. Forced crossings may be a response to particular environmental conditions that a specific type of pedestrian makes.

5. Appendix 30 shows the minimum, maximum, mean and number of kerb/road wait times for each site and for all sites together, and the midway wait times for all sites. 36 of the 694 (5.2%) pedestrians observed waited at midway. All of these midway waits occurred at Tottenham High Road, where one direction of traffic was often queued back, and at Willow Road which was the widest road observed (14.46 metres).

The range of kerb/road wait times at all sites is shown in figure 23. This shows 408 of the 421 observations. The other 13 observations are shown as outliers in figure 24 and ranged up to 127.2 seconds. Most of these longer waits occurred at Lancaster Road. Figure 23 shows that approximately one third of pedestrians waited less than two seconds. The shortest kerb/road wait times are probably solely made up of the decision-making time. More than a half crossed within 4 seconds, and as with previous research (Hunt and Griffiths, 1991), only a small proportion waited more than 30 seconds.

Figure 23: Number of Pedestrians by Kerb/Road Wait Time at All Sites



The overall mean kerb/road wait time was 8.8 seconds, which is similar to the mean delay of 8 seconds recorded in the West Midlands (op. cit). This included a few crossings (all at Station Road) where there was a zero kerb/road wait time as there were no cues that the pedestrian was about to start crossing, hence no decision making time was observed. This behaviour was rare.

Figure 24 shows the range of kerb\road wait times at each site and day. The boxes show that the semi inter-quartile range at all sites and days is at the lower end of the range of kerb/road wait times, and the longest kerb/road waits are more widely spread. This shows that all sites some pedestrians have been prepared to wait for long periods of time. The shortest kerb/road wait times (mean = 6.0 seconds) occurred at Station Road. This was probably due to the walk and look strategy that commuters travelling to the train station often used. The longest kerb/road wait times (mean = 14.8 seconds) occurred at the wider Willow Road. This may have been because the length of crossing required pedestrians to wait longer for a larger gap.

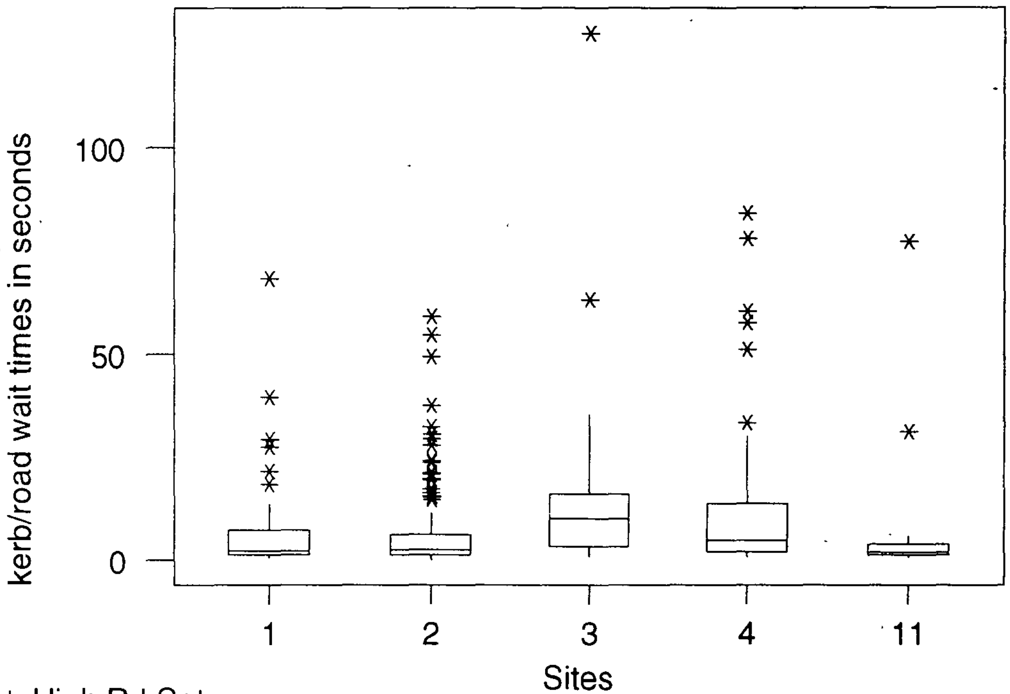
A two sample t test was done to test the null hypothesis:

> There will be no significant difference between pedestrians' wait times on the kerb and in the road.

The null hypothesis was rejected; results showed that there was a highly significant difference ($N = 421$, $T = -6.66$, $p = < 0.00005$) in waiting time between pedestrians that had moved into the road before crossing and those that had not. Pedestrians who moved into the road waited longer (mean 19.6 seconds) than those who did not move into the road (mean 5.2 seconds). This is further evidence that moving into the road is a response to environmental conditions.

Table 27 shows the mean kerb/road wait time for each age and sex group, together with the number of observations of each. This shows that there is a far shorter kerb/road wait time for males in the 15-59 age group than for any other group. Younger and older males have similar wait times to women.

Figure 24: The Range of Kerb/Road Wait Times at Each Site and Day



1 = Tot. High Rd Sat.

11 - Tot. High Rd. Mon. 2 = Station Rd 3 = Willow Rd. 4 = Lancaster Rd

Table 27. *Number of Observations and the Mean Kerb/Road Wait Time for Each Age and Sex Group.*

Age	(Number of Subjects and Mean Kerb/ Road Wait Time in Seconds.)		
	Female	Male	All
1 0-14	9	7	16
	12.2	10.9	11.6
2 15-59	177	177	354
	10.3	5.6	8.0
3 60+	30	20	50
	15.0	12.2	13.8
All	216	204	420
	11.1	6.4	8.8

A Generalised Linear Model (GLM) was used to test the null hypothesis:

> The age group and sex of pedestrians will not explain the variability in kerb/road wait time.

Results showed that age and sex did help explain kerb/road wait time (age $F = 3.60$, $p < 0.028$; sex $F = 10.43$, $p = <0.001$), and the null hypothesis was rejected. Women wait longer than men, and children and elderly people wait longer than adults aged 15-59.

In summary, the results on kerb/road wait times suggest that in certain environmental conditions, some pedestrians are prepared to wait for long periods for a safe gap. Although it appears that men in the 15-59 age group will probably use some other strategy rather than wait. Overall, the results show that many pedestrians try to reduce delay.

9.3 ANGLE OF CROSSING FROM THE PERPENDICULAR

Appendix 31 shows the number and percentage of pedestrians that crossed the first and second leg of the road at 0-15, 16-30, 31-45 and less than 45 degrees from the perpendicular. For all sites, approximately three quarters of crossings were within 15 degrees of the perpendicular (leg 1 =79.5%; leg 2 = 71.3%). More angled crossings may have occurred on the second leg than the first because people try and continue in the direction they are going once the first leg has been completed. These results confirm Grayson's (1975a) findings that when environmental conditions allow, many pedestrians may make angled crossings to reduce their journey time.

There was a considerable variation in the pattern of crossing angles between sites, and at Tottenham High Road on the Saturday and Monday. A Chi-squared test was done to test the null hypothesis:

> The site and day of the week on which crossings take place will not significantly affect the angle from the perpendicular that pedestrians take.

The results confirmed that there was a significant difference between sites/day of the week in the angles taken (first leg angle N =825, chi-squared = 94.502, $p < 0.00005$; second leg angle N =824, chi-squared =98.778, $p < 0.00005$), and the null hypothesis was rejected. The larger number of crossings within 15 degrees of the perpendicular at Tottenham High Road on Saturday than on Monday (Saturday leg 1 = 90.7% and leg 2 = 80.6% compared to Monday leg 1 = 64.5% and leg 2 = 63.9%) may have been due to the increased vehicle flow (see section 9.1.3). Higher vehicle flows may result in less opportunity for safe angled crossings; it also leads to queuing traffic which would make angled crossings quite difficult. Station Road included more angled crossings as the commuters took the quickest path to the station. Willow Road had nearly all crossings that were within 15 degrees from the perpendicular (99% and 95%) as it was a wide road (14.46 metres). Lancaster Road had by far the greatest percentage of crossings that were more than 45 degrees from the perpendicular (leg 1 = 10% and leg 2 = 16%). This was probably because parked cars on one side of the road reduced the already small width of the road, making sharply angled crossings more manageable.

Finally, the angles from the perpendicular that were used did not vary according to the age or sex of the pedestrian.

9.4 PEDESTRIAN SPEED AND CROSSING TIMES

The minimum, maximum, mean and number of observations of time-to-midway, second leg crossing time and total unbroken crossing time for each site and for all sites are in appendix 32. In addition, the walking speeds (in metres per second) for each leg of crossing, which were calculated by taking into consideration the road width and the approximate angle of crossing, are also given. At Station Road the road width varied along the site length so the mean value was used.

Crossing speed takes into consideration the crossing time, angle and road width, and hence enables crossings to be compared with each other. The crossing speeds showed a considerable range of values for both legs (leg 1 = 0.6 - 3.7 metres per second; leg 2 = 0.5 - 3.8 metres per second). (Figure 25a and b)

The mean walking speeds are similar to men's preferred velocity of 1.34 metres per second (Kurosawa, 1994). Also, they show that at all sites people walk slower on the second leg than the first (all sites mean, time to midway = 3.3 seconds, 1.5 metres per second; second leg cross time = 3.8 seconds, 1.4 metres per second). A one sample (related) t test was done to test the null hypothesis:

> There will be no significant difference in pedestrians' walking speed on the first and the second leg of crossing.

Results showed that this difference was significant ($N = 446$, $T = 6.24$, $p < 0.00005$), and the null hypothesis was rejected. This, like the increase in crossing angles on the second leg, may be explained by pedestrians' feeling more confident as they near the kerb. The shorter distance left to travel allows them to make a better estimate and so they are progressively more sure that they have plenty of time left to reach the kerb. The behaviour results from perceiving that there is less threat.

Figure 25a: Number of Pedestrians by Walk Speeds for Leg 1 at All Sites.

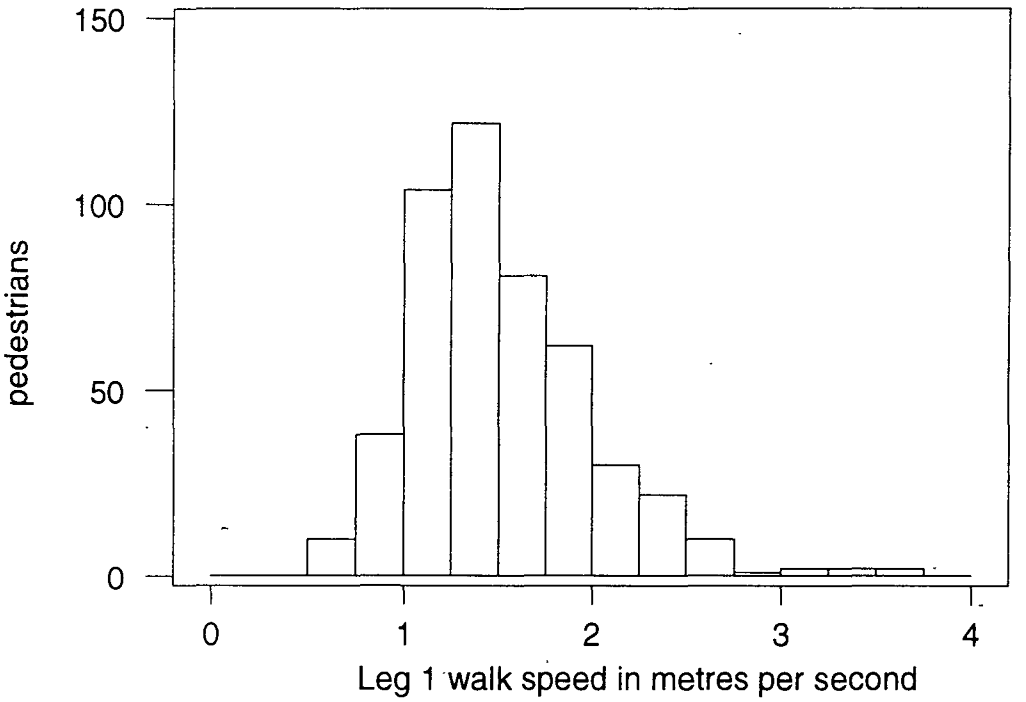
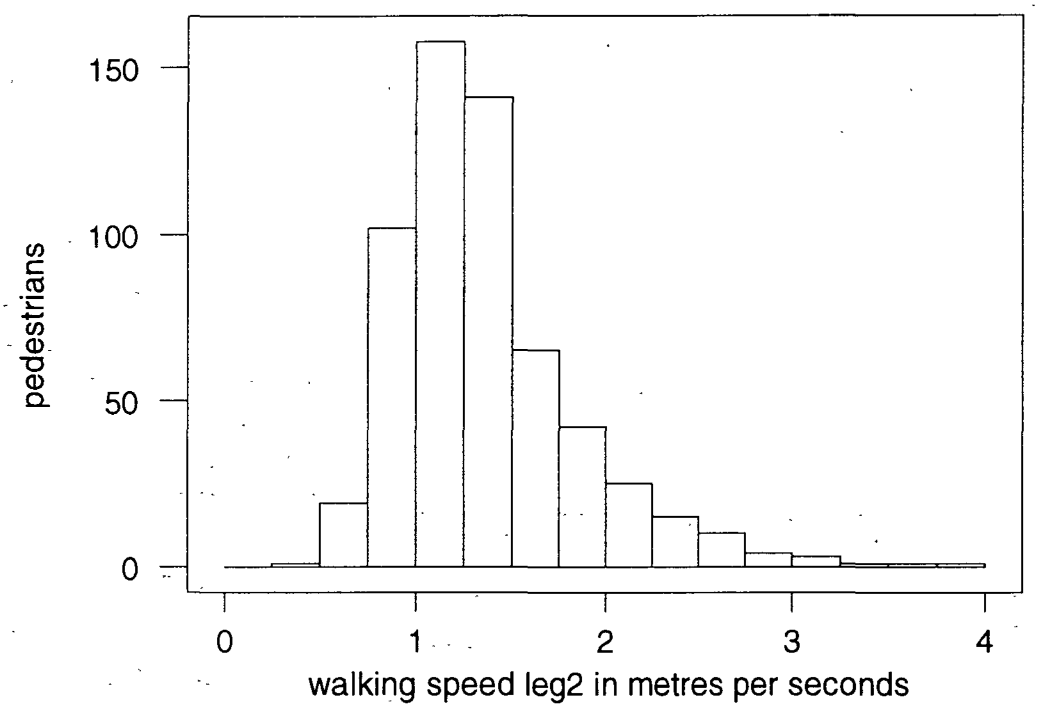


Figure 25b: Number of Pedestrians by Walking Speeds for Leg 2 at All Sites



This result implies that first leg crossing speed is faster than pedestrians footway walking speed, the latter of which is likely to be their preferred walking speed. First leg crossing speed would be faster than footway walking speed in order to reduce exposure and risk. Future research would usefully assess whether first and second leg crossing speed varies from footway walking speed, the range in any variations that occur, and the conditions that might produce them.

The range of crossing speeds for each leg of crossing at each site are shown in figure 26a and b. Generalised Linear Models were used to test the null hypotheses that:

> The site and day of the week will not help explain the variability in pedestrians walking speeds a) on the first and b) the second leg of crossing.

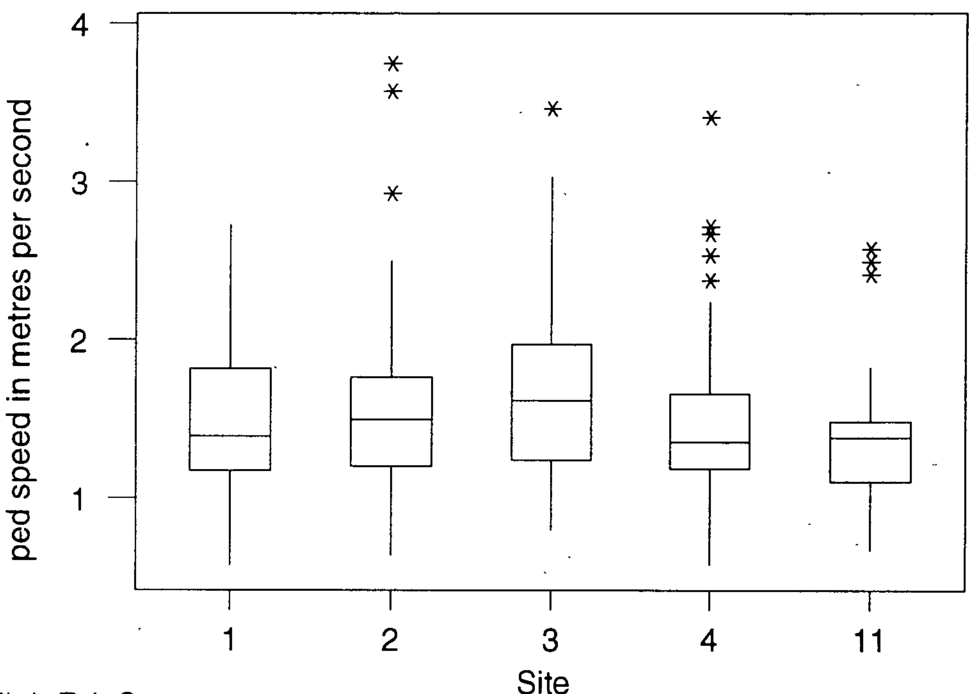
Results showed that there were different walking speeds at the different sites and days (leg 1, $F = 3:14$, $p < 0.014$; leg 2, $F = 14.91$, $p = < 0.0005$). This may mean that people change their walking speed according to the environment they are in, and from day to day.

Two sample (unrelated) t tests were done to test the null hypotheses:

> There will be no significant difference in walking speed between encumbered and non-encumbered pedestrians on a) the first and b) the second leg of crossing.
>
> There will be no significant difference in walking speed between accompanied and unaccompanied pedestrians on a) the first and b) the second leg of crossing.

Results showed that encumbered pedestrians walked significantly slower on the first leg of crossing ($N = 486$, $T = 2.08$, $p = <0.044$) than non-encumbered pedestrians, but not on the second leg ($N = 589$, $T = 1.37$, $p = < 0.18$). A similar picture emerged for accompanied pedestrians, with first leg crossing speed reaching significant statistical levels ($N=486$, $t = 2.80$, $p = <0.0062$) but not second leg ($N = 589$, $t= 0.85$, $p = < 0.40$). Although significant, the largest mean difference in walking speed was quite small.

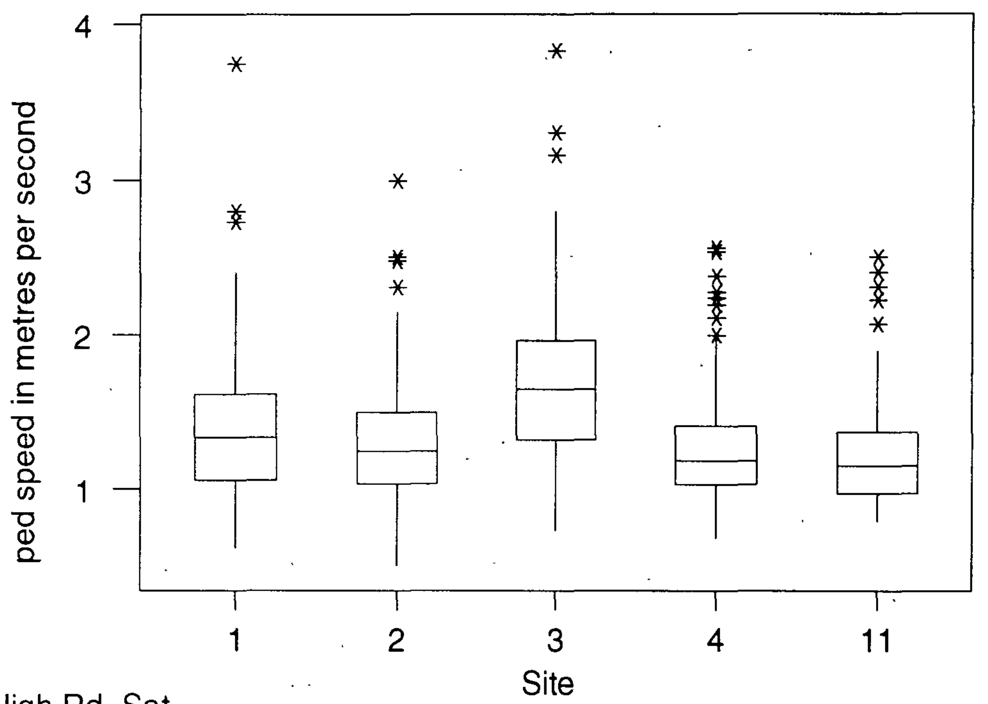
Figure 26a: The Range of First Leg Pedestrian Speeds at Each Site and Day



1 = Tot High Rd. Sat.

11 = Tot. High Rd. Mon. 2 = Station Rd. 3 = Willow Rd. 4 = Lancaster Rd.

Figure 26b: The Range of Second Leg Pedestrian Speeds at Each Site and Day



1 = Tot High Rd. Sat.

11 = Tot. High Rd. Mon. 2 = Station Rd. 3 = Willow Rd. 4 = Lancaster Rd.

Table 28 shows the number of observations and the mean walking speed for both legs of crossing for each age and sex group. This confirms previous research (OECD, 1985) that walking speed gradually decreases with age for both sexes. Also, males in all age groups, especially children, walk faster than their female counterparts. Young boys walked approximately 0.5 metres per second faster than any other group on both legs of crossing.

Generalised Linear Models were used to test the null hypotheses:

> The age group and sex of pedestrians will not explain the variability in walking speed on a) the first and b) the second leg of crossing.

Results showed that only age was a significant factor (first leg, age $F = 6.56$, $p < 0.002$; sex $F = 2.44$, $p = <0.119$; second leg, age $F = 15.13$, $p = <0.0005$, sex $F = 2.75$, $p = < 0.098$). As noted above the second leg walking speed is slower than the first leg. However, the limited observations of children show a slight increase in walk speed for the second leg. More data on children's crossings would have been useful.

Overall, the results confirm previous research reported in chapter 6 that environmental conditions, age and sex are associated with large variations in pedestrian crossing times and speeds.

9.5 SPEED OF INTERACTING VEHICLES

Appendix 33 shows the minimum, maximum, and mean vehicle speeds (in miles per hour), and the number of observations for vehicles that interacted with pedestrians:

a) upstream (50 metres from the crossing place) and

b) at the crossing place (where the pedestrian crossed).

Both legs of crossing are combined at each site and for all sites. The overall mean upstream vehicle speed was 23.1 miles per hour. Few observations were made at the Tottenham site due to difficulties in selecting the vehicle that interacted with the pedestrian. Generally, the need to select vehicles 50 metres before the crossing point would prevent data on risky crossings being collected.

Table 28. *Number of Observations and the Mean Walking Speed in Metres Per Second for Both Legs of Crossing for Each Age and Sex Group.*

Leg	Age	(Number of Subjects and Mean Waking Speed in Metres Per Second) Female	Male	All
	1 0-14	8	15	23
L		1.5	2.0	1.8
E	2 15-59	186	231	417
G		1.5	1.6	1.5
1	3 60+	22	23	45
		1.3	1.4	1.4
	All	216	269	485
		1.5	1.6	1.5
	1 0-14	13	17	30
L		1.6	2.2	1.8
E	2 15-59	234	259	493
G		1.3	1.4	1.4
2	3 60+	37	29	66
		1.2	1.2	1.2
	All	284	305	589
		1.3	1.4	1.4

The mean upstream and crossing place speeds within individual sites and for all sites are quite similar. However, in all cases the crossing place speed is slightly lower than the upstream speed. And, as stated above this is for a sample of less risky crossings. This suggests that either drivers interacting with pedestrians feel the need to reduce their speed, even in low risk conditions, or the type of low risk crossing where vehicle speeds were collected are characterised by the vehicle slowing. Figure 27a and b illustrate the range of upstream and cross place speeds at all sites.

A one sample (related) t test was done to test the null hypothesis:

> There will be no significant difference in the speed of vehicles interacting with pedestrians at the place where the pedestrian crossed and 50 metres before.

The null hypothesis was rejected as there was a significant difference ($N = 240$, $T = 8.27$, $p =< 0.00005$). Vehicles slow slightly either to let pedestrians cross, or for other reasons. Pedestrians may then make use of the resulting gap.

Far higher maximum and mean speeds were recorded at the wider Willow Road, which also has a low vehicle flow index (see section 9.1.3). A low mean vehicle speed was recorded at the narrower Station Road which has a high vehicle flow index. These results, which illustrate the range in mean speeds between sites, show that general environmental conditions help explain drivers' choice of vehicle speed, as well as personal factors like preferred level of risk, and incidental factors like the speed of the vehicle in front.

9.6 GAP ACCEPTANCE

Gap acceptance is the most important of the variables collected because the IPD user's perception of what is an appropriate minimum gap will colour his or her response to the device in action. The gaps pedestrians accept depend, to some extent, on the gaps that are available. Larger gaps than the smallest acceptable gap (critical gap) can be accepted. Hence, it is likely that vehicle flow plays an important role. It has already been shown that vehicles often slow when interacting with pedestrians. This may also influence gap acceptance.

Figure 27a: Number of Vehicles by Upstream Vehicle Speeds at All Sites

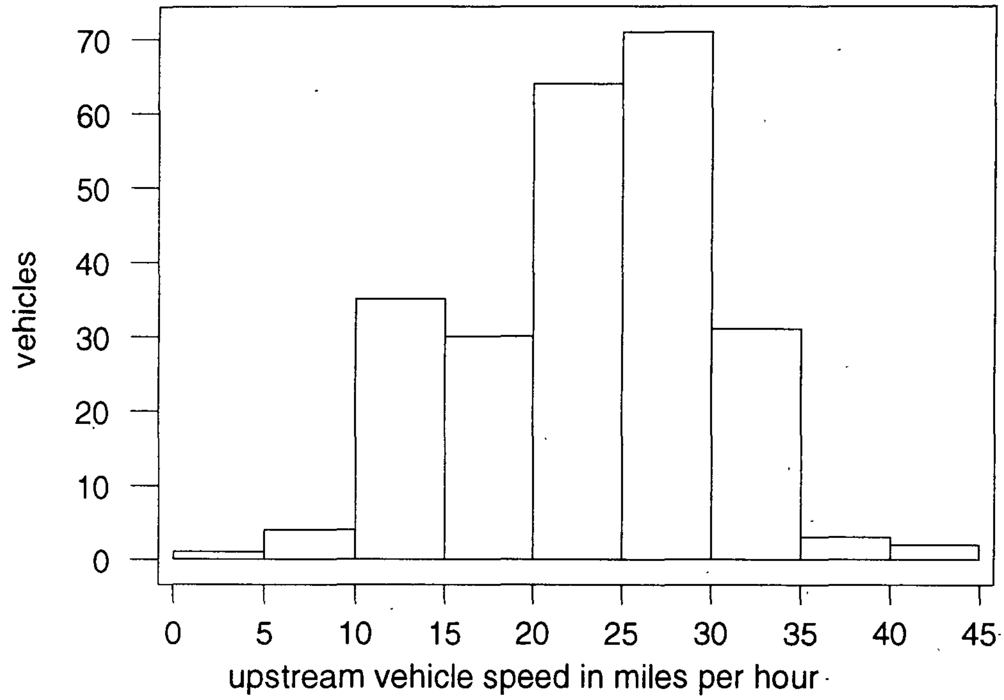
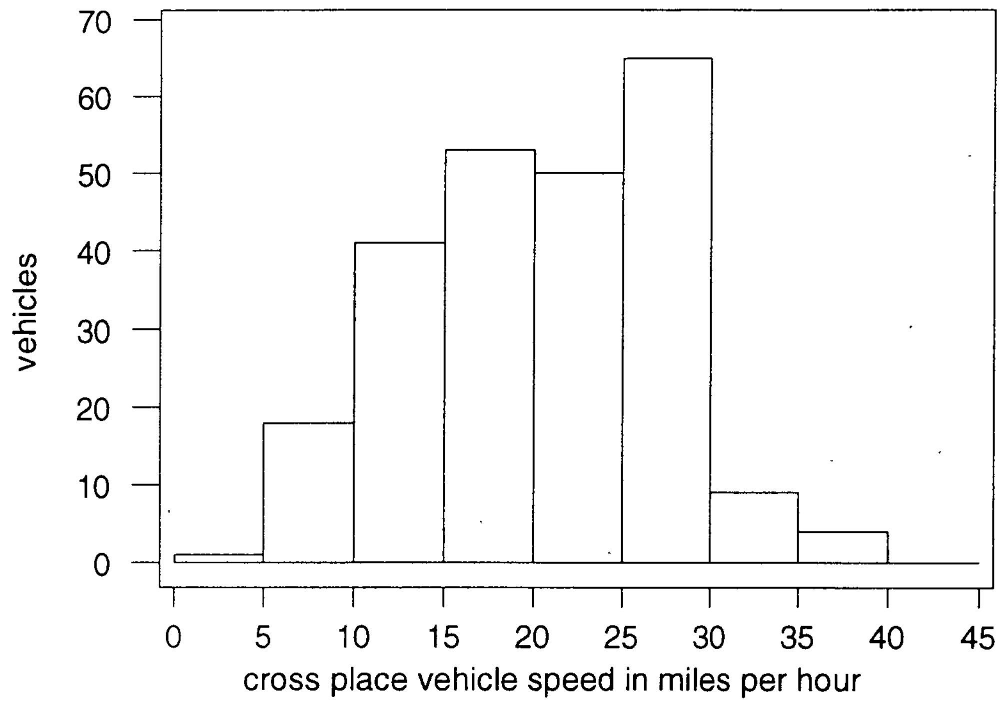


Figure 27b: Number of Vehicles by Cross Place Vehicle Speeds at All Sites



Observation of the gaps accepted at all sites showed that most people waited for a simultaneous gap on both legs of crossing rather than weave through the lanes. This is consistent with the low number of forced crossings and midway waits recorded. People chose larger gaps to cross in than the gaps and lags they had rejected, indicating that any impatience experienced due to delays did not result in making risky crossings. Approximately 50% of pedestrians observed did not interact with a vehicle or crossed between stationary vehicles.

Appendix 34 gives the number of observations, minimum, maximum and mean gaps accepted for both legs of crossing, for each site and for all sites. In addition, the safety margins, which were calculated by subtracting the time taken to cross each leg from the gap accepted, are also given. This calculation sometimes results in a negative time safety margin. This is because for some crossings, the vehicle may have passed the pedestrian's crossing place before the pedestrian actually reached midway or the kerb. Obviously, these represent more risky crossings.

The mean second leg gap accepted and safety margin are smaller than those for the first leg (overall means: gap 1 = 7.1 seconds, gap 2 = 5.2 seconds; safety margin 1 = 4.3 seconds, safety margin 2 = 1.2 seconds). The difference in the range of first and second leg gaps accepted at all sites can be seen in figure 28a and b.

One sample (related) t tests were done to test the null hypotheses:

> There will be no significant difference between the a) gaps accepted and b) safety margins on the first and the second leg of crossing.

Both null hypotheses were rejected (gaps accepted, $N = 156$, $T = 7.39$, $p = < 0.00005$; safety margins, $N = 123$, $T = 7.17$, $p = < 0.00005$). One explanation may be that pedestrians waiting to cross the road, assess their path giving more importance to vehicles coming from the first flow of traffic. For example, a pedestrian waiting to cross may:

Figure 28a: Number of Pedestrians by First Leg Gaps at All Sites

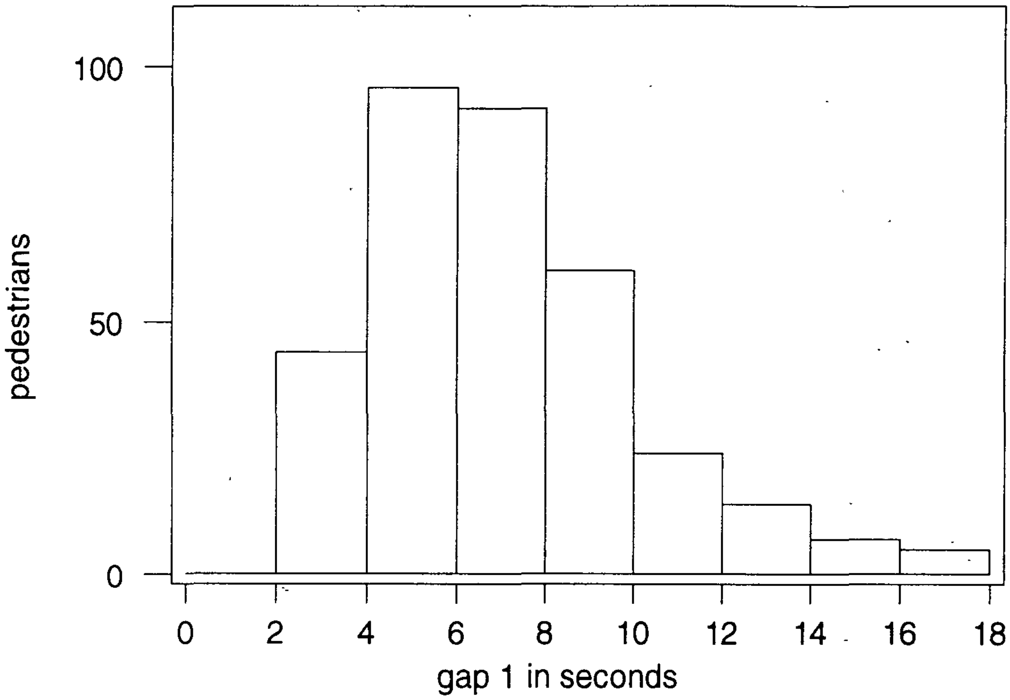
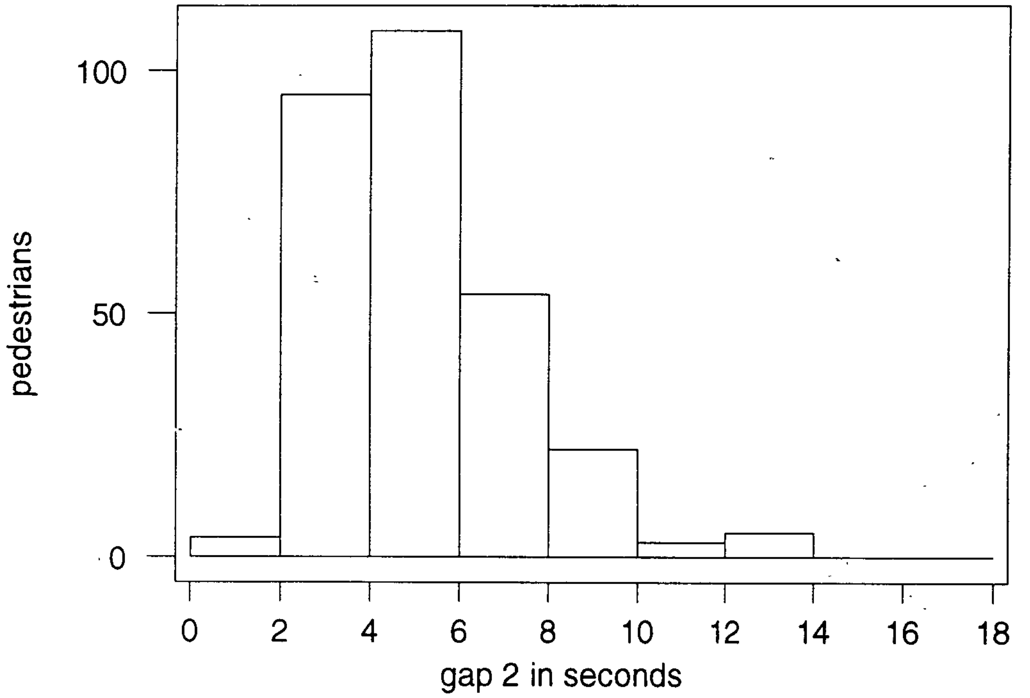


Figure 28b: Number of Pedestrians by Second Leg Gaps at All Sites



-perceive a gap of 7 seconds on the nearside of the road and 7 seconds on the far side,

-take 2 seconds to cross half way, and be left with a 5 second gap on the far side.

The slower second leg walking speeds (see section 9.4) may help explain the smaller safety margins. Pedestrians slow down and 'use up' the second leg gap they accepted. The minimum safety margins (see appendix 34) show that this may result in finely balanced judgements about the remaining time available. It also helps confirm that pedestrians' first leg crossing speed may be much faster than their footway speed. This confirms Older and Grayson's (1974) findings that increases in walking speed are used as a strategy to find acceptable gaps and reduce delay.

Appendix 35 gives the number of observations, mean gap accepted and safety margins for both legs of crossing, for each age and sex group. These results confirm that for all age and sex groups, gaps and safety margins are smaller on the second leg. Contrary to previous research reported in chapter 6, no age or sex differences in the gaps accepted on the first or the second leg of crossing were found. However Generalised Linear Models were used to test the null hypotheses:

> The age group and sex of pedestrians will not explain the variability in safety margins on a) the first and b) the second leg of crossing.

On the first leg sex was a significant factor but age was not (age $F = 0.58$, $p = < 0.564$; sex $F = 5.44$, $p = < 0.021$), and for the second leg of crossing age was a significant factor and sex was not (age $F = 5.97$, $p = < 0.003$, sex $F = 0.95$, $p = 0.331$). The results show that women allow a longer safety margin than men on the first leg of crossing, perhaps because they begin more cautiously. For the second leg safety margins, the overall means for each age group show that the 0-14 and 15-59 age groups are similar (0-14 = 1.7 seconds; 15-59 = 1.8 seconds), whereas the 60+ age group is lower (1.1 seconds); probably because of their slower walking speed. Further investigation of the elderly's lower safety margins reveals that it is elderly women whose safety margin is much lower than the other groups (60+ females mean = 0.5 seconds; 60+ males mean = 2.1 seconds). This may be because women tend to live longer than men, and hence the average age of the sample of women is likely to be older than the average age of the sample of men. This result should be viewed cautiously as the number of elderly people in each category was quite small (females n = 22; males n = 14). However, it could help throw more light on Carthy et al's (1995) research, reported in chapter 6, which found that elderly pedestrians often do not pay enough attention to the second half of their crossing.

To test the null hypothesis that:

> independent variables (listed in table 29 below) will not explain the variability in a) gap accepted on the first leg of crossing and b) gap accepted on the second leg of crossing,

stepwise backward regression analyses were carried out. The table (29) notes independent variables with nominal data that were converted to dummy variables. Variables marked with an asterisk are those that were selected by the analyses.

Due to missing data, mostly on the dependent variables of first and second leg gap accepted, and the independent variables of kerb/road wait and pedestrian speed, the number of observations used in the regression analyses was 236 for the first leg and 264 for the second leg. Also, it had been hoped to include upstream speed as an independent variable, but including the 240 observations in this category reduced the sample available for the regression analysis to an inadequate size. Regression analyses of first and second leg gap accepted with upstream speed as the sole dependent variable showed that, contrary to previous research reported in chapter 6, on their own they did not emerge as significant factors in explaining gaps accepted.

Detailed results together with plots of the fitted models for gap accepted, and standard residuals, are given in appendix 36. Both regressions were significant (leg 1, $F = 10.09$, $p < 0.0005$; leg 2, $F = 8.34$, $p = < 0.0005$). The value of R-squared for each analysis was:

leg 1 = 20.9% leg 2 = 18.6%

Table 29. *Independent and Dummy Variables Used in the Backwards, Stepwise Regression Analyses for the Dependent Variables, First Leg Gap Accepted and Second Leg Gap Accepted.*

	Gap Accepted	
	First Leg	Second Leg
Independent Variables	kerb\road wait	*midway wait
	1st leg vehicle flow	2nd leg vehicle flow
	ped.flow nearside pavement	*ped. flow farside pvmnt.
	pedestrian crossing flow	pedestrian crossing flow
	*1st leg ped. cross speed	*2nd leg ped. cross speed
Dummy Variables	visibility	*visibility
	*accompanied	accompanied
	*encumbered	encumbered
	*vehicle type	vehicle type
	*age	*age
	sex	sex

* = variables selected for use in the final regression analysis.

These are quite low, and hence the models are not very explanatory. This is expected as accepted gap is partly a function of traffic flow. A preferred model would be for critical gap, but the data for this was not available. The following compares the results reported previously with the results from the regression analysis.

Kerb\road wait time did not emerge as a predictor of first leg gap, but midway wait was a predictor for second leg gap. This may have been due to the exclusion of gap acceptance observations in which pedestrians first stood in the road; essentially reducing 'kerb/road wait time' to 'kerb wait time' for this analysis. Analyses reported earlier showed that moving into the road, age and sex all helped explain kerb/road wait time. It seems likely that kerb/road wait time would have helped explain first leg gap acceptance if all of the road wait time observations were included in the regression analysis.

Also, visibility did not emerge as a predictor of first leg gap, but did for second leg gap. Analysis reported earlier showed that pedestrians who waited in the road were more likely to have low levels of visibility than those who did not. Hence, the fair and bad levels of visibility are more likely to have been removed from the regression analysis and prevented visibility from emerging as a significant factor.

Speed of the pedestrian was the best predictor of both first and second leg gaps accepted. As found in previous research reported in chapter 6, pedestrians select larger gaps if they know they walk slower. Results reported earlier in this chapter showed that on the second leg of crossing, pedestrians walked slower and accepted smaller gaps. Hence, the relationship of pedestrian speed to the gap accepted is different on the first and the second leg of crossing.

Interestingly, unlike previous research reported in chapter 6, vehicle flow was not a predictor of either gap. However, it was seen earlier that first leg vehicle flow helped explain kerb\road wait, and second leg vehicle flow helped explain second leg pedestrian speed, so clearly the flow has some influence, albeit small.

Results concerning encumbered and accompanied pedestrians confirmed that both have an effect on first leg gap acceptance. Results reported previously in this chapter showed a relationship between these variables and first leg walking speed. Accompanied and encumbered pedestrians walk slower and require larger gaps, but only on the first leg of crossing. Perhaps, pedestrians who are not encumbered or accompanied walk faster than their footway walking speed on the first leg, but encumbered and accompanied people do not; they maintain a steady pace.

The type of vehicle that the pedestrian crossed in front of was a significant factor in explaining gap accepted on the first leg of crossing but not on the second leg. Type of vehicle was expressed in terms of dummy variables. Two-wheeler, car and van were compared against the lorry\bus category. Two wheeler did not emerge as a significant factor but car and van did. Results showed that pedestrians require smaller gaps when they cross in front of a van or a car than they do when they cross in front of a lorry/bus on the first leg of crossing.

Age emerged as a significant factor in explaining first and second leg gap acceptance. Age was also converted to dummy variables and 0-14 and 15-59 were compared against age 60+. Age 0-14 emerged as significant for the first leg of crossing and both 0-14 and 15-59 were significant for the second leg of crossing. The results showed that these groups had larger gaps than the 60+ group. Generalised Linear Models reported earlier found no age differences in the gaps accepted, and this is confirmed by the means for each age group (see appendix 35). However, there were significant age differences in safety margins (which include the time taken to cross). It is therefore likely that other factors used in the regression, probably walking speed, mediated the influence of age.

Finally, two other factors that did not emerge as significant predictors of gap acceptance in the regression analyses may be worthy of further mention. Previous analyses did show that there were some sex differences in pedestrian behaviour e.g. females had much longer kerb/road wait times than males. Hence, sex may affect other behaviours that in turn affect the gap accepted. Secondly, vehicle speed did not predict gap acceptance, but previous results (see section.9.5) showed that vehicles slow when pedestrians cross the road. Pedestrians may subconsciously consider this deceleration in making their judgement. This subconscious judgement may be part of the social barometer we use to assess risk that was discussed in chapter 5, and is further discussed in section 11.1.3.

9.7 IMPLICATIONS OF THE RESULTS FOR THE IPD.

The following outlines the implications of the results for the design and use of a portable IPD. First, problems related to pedestrians' choice of crossing place are discussed, second, the cues to crossing are outlined and third, behaviours observed during crossing are discussed. The aim is to outline how the portable IPD could work safely with as little inconvenience to the user as possible.

Pedestrians often crossed with fair or bad visibility. This would be unacceptable if it impeded the functioning ability of the IPD. Ideally, the IPD would be able to cope better with obscured vision than humans, but if it did not then perhaps it could advise users that the environmental conditions were unacceptable. Also, where wait times exceed a certain level, the IPD could advise users that it might be wise to select another crossing time or place.

Crossing near parked and stationary vehicles was frequently observed. Apart from problems related to obscured vision, this is risky for pedestrians because the vehicle can begin moving. Ideally the IPD would be able to distinguish between parked and engine-running vehicles, and it would not advise crossing in front of the latter. In some circumstances this would increase delay or cause a detour to be made, and hence may discourage pedestrians from using the IPD. Safe crossing in a situation like this is usually managed by communicating non-verbally with drivers about who has precedence, and relying on the driver's discretion. An IPD could not communicate in this way, although it is conceivable that vehicles could at some time in the future be fitted with devices that interact with an IPD and effectively force the driver to give way.

Crossing with no discernable human cue (e.g. head movement) was rare, although the cues were often very subtle. Cues to a pedestrian's impending crossing could be interpreted by the IPD from the pedestrian's position and orientation in the road environment. However, in some cases, it would be very difficult for IPDs to perceive any of these cues well enough to accurately predict an impending crossing. For example, the commonly observed walk and look strategy for finding a safe gap could make it difficult for the IPD to predict when the pedestrian was intending to cross. If the IPD was not sure if the user wanted to cross the road it could continually monitor and advise, at short intervals, whether or not it was safe to cross (this is an active device that does not require users to ask for advice about crossing). However, users would almost certainly become overloaded with information or ignore the device if it gave a continuous flow of information for long periods of time. Users could be advised that any behaviour on the footway that could be construed as anticipating a crossing e.g. orientation towards the road or walking near the kerb would activate advice from the IPD.

Alternatively, passive devices, that is, those that respond to the user's request to cross the road could be used. Passive devices are not as efficient because they would not prevent accidents that occur due to sudden impulse. Nor are they as convenient, as users have to operate the device. However, the wait times observed in these urban areas suggest that provided the IPD was accessible, many pedestrians would have enough time to make the request without causing themselves extra delay.

None of the sites observed had refuges, yet a small number of pedestrians made a two-stage crossing, that is, they stopped in the middle of the road. Waiting in the road can be dangerous, and it is not possible to know a person's intention to stop midway. Hence, IPDs would not advise crossing unless large enough gaps were available in both directions. Where refuges are present IPDs could be programmed to recognise them and advise on the safety of crossing in two stages.

A quarter of the pedestrian crossings observed were not approximately perpendicular to the kerb. This behaviour is not necessarily risky, but IPDs could find it difficult to predict. Allowing for crossing a long way from the perpendicular could involve having to wait for larger gaps, and therefore cause delay. The IPD could require users to make an approximately perpendicular crossing, but this might make the IPD unpopular because it would extend some pedestrians' journey times. Users could give the IPD information about the angle of crossing to be made, although this is unlikely to be a very useful function as the evidence suggests that pedestrians tend to cross away from the perpendicular spontaneously, when the opportunity arises to safety continue following a path in the direction they are travelling.

IPDs could infer angle of crossing from the direction that the pedestrian is facing, but accurately identifying the pedestrians' projected path could be difficult, especially if pedestrians change their intentions. To ensure safety it would be best to advise users to cross approximately perpendicularly to the kerb, or to cross in the direction they are facing without changing orientation at any time. Functions related to crossing angle will be very important for visually restricted pedestrians as they may need to rely of the IPD to ensure that they do not deviate too far from the intended line of motion.

Several factors were found to affect pedestrian walking speed. Calibrating the device to the pedestrian's present footway walking speed would seem to be the best option to ensure that sufficient safety margins are allowed. There was evidence that pedestrians use different walking speeds on the footway and when crossing the road, and they change their walking speed mid crossing. The IPD would use a constant walking speed. If a pedestrian decreases his or her walking speed mid-crossing this could cause problems as it would erode the safety margin. The IPD could advise pedestrians not to decrease their walking speed mid-crossing if they became threatened by a vehicle.

The gaps accepted by pedestrians were partly explained by several of the independent variables. However, a large part of the variance was not explained. Gap acceptance behaviour involves a complex decision making process; far more complicated than that which an IPD would use. Walking speed was the most significant of the observed variables for both first and second leg gap. Pedestrians accepted larger gaps if they walked more slowly for both legs of crossing. However, there was a different relationship between walking speed and gap accepted on the first and the second leg of crossing. Pedestrians walked slower on the second leg of crossing and accepted smaller gaps. The results suggest that there is a complex interaction of variables involved in gap acceptance which is mediated by pedestrian speed: the pedestrian may increase or decrease his or her speed to regulate the size of the safety margin. The IPD would not do this, and hence may be unpopular with some pedestrians. However, it would improve safety.

There was some evidence of differences between people in their preferred safety margin. Calibrating the device to an individual's preferred safety margin (not below a set amount of time) would help allow for these differences, and may help prevent users perceiving the IPD as too cautious.

In order to prevent being delayed in congested conditions, some pedestrians used risky behaviours (e.g. crossing with a small safety margin, suddenly increasing their crossing speed or forcing a crossing). The IPD would not advise crossing in these conditions. Some pedestrians may find using these risky behaviours acceptable, and feel that the IPD is too cautious for their liking. Evidence suggested that it is middle age group males who are prepared to take more risks: they had smaller kerb/road wait times and safety margins than any other age or sex group, Hence, this group may be less likely to appreciate the IPD.

In conclusion, the results concur with Hunt and Griffiths findings (1991) that pedestrians use many strategies to avoid or reduce delay. Hence, to encourage social acceptance pedestrian aids should try to keep delay to a minimum. People may change their crossing strategies if they value safety. Pedestrians who prefer to modify their behaviour according to the road environment in order to reduce delay to a minimum will probably never buy an IPD.

9.8 EVALUATION OF THE METHOD.

The choice of the method of video observation of pedestrians in their natural setting is discussed in section 8.1. Overall, this method was useful in helping discover most of the required information.

What follows is a description and discussion of some of the main problems encountered in using this method, and analysing the resulting data. The following three subsections describe the problems: retrieving the data from the site, retrieving the data from the video recordings, and using the video analysis equipment. Where possible, suggestions are given for improving future research.

9.8.1 Obtaining Data.

It was intended to include sites with a range of vehicle flows. Unfortunately, during the observation period at the Tottenham High Road site, high vehicle flow often caused queuing. This prevented gap acceptance data from being collected, and sometimes obscured visibility. Conversely, all the other sites had periods of low vehicle flow which meant there were very large lags. The resulting data reflect the real situations that pedestrians are faced with, but they do not offer as much of the important gap acceptance data as was intended. Future work might profitably target only those crossings that involve gaps close to the minimum acceptable ones, and use a method for estimating critical gaps.

To ensure the capture of all the data from each pedestrian crossing movement would have meant using far more sophisticated data collection and analysis techniques, or selecting only those movements where it was possible to observe all the behaviours of interest; this, in itself, could cause a sampling bias.

9.8.2 Retrieving Data.

Two types of data were difficult to collect on site. Firstly, observing a large length of road sometimes made it difficult to ascertain the pedestrian's age and sex group; secondly, selecting cars that interacted with pedestrians crossing the road was often difficult. These problems occurred especially at times of high vehicle and pedestrian flow. Also, occlusion by vehicles sometimes made it difficult to observe the pedestrian's crossing movements.

When retrieving data from the video recordings, high pedestrian flow conditions and long site length also made it difficult to ascertain which verbal information related to which pedestrians. In future, reducing the site length of busy roads, and more careful selection and noting of the details of pedestrian crossings on site would improve data retrieval. Data retrieval was already very time consuming. A method of reducing retrieval times is discussed in the following sub-section.

Another complication in data retrieval was that Station Road varied in width between 5.95 and 8 metres. This, together with the fact that pedestrians made angled crossings, made it difficult to assess the path length of each pedestrian crossing movement. Future research should exclude sites with varying road width or take careful measurement of path lengths.

9.8.3 Video Analysis Equipment.

A big problem in data retrieval was that the audio taped material collected on site did not synchronise with the video tape (see section 8.3.2). This sometimes made it extremely difficult to decide which audio information about a pedestrian appertained to which video information. This was resolved by painstakingly marrying up the two bits of information, either from the two different places that they occurred on the video recording, or from the video and audio recordings. In future, it might be better to transfer the on site information by two way radio straight onto the video recording. Alternatively, two views from two video recordings of the road would allow two soundtracks and would improve the quality of data retrieved. Both of these solutions would be more expensive.

More sophisticated video analysis equipment which could recognise pedestrian and vehicle interactions and movements would reduce processing time (Rourke and Bell, 1994). This would prevent many of the problems experienced in this study. For example, it would aid analysis of sites where there is low pedestrian crossing flow, and allow interactions of specific interest to be selected more easily.

9.9 CONCLUSIONS.

A total of 906 pedestrian crossings were observed at four urban sites, totalling 243 metres, over 11 hours 45 minutes. None of these sites were designated crossings, so all of the pedestrians freely chose their own crossing place. The results show that pedestrians use a wide range of behaviours to cope with the environment that they are faced with, and these behaviours may vary for any given pedestrian, between the first and second leg of crossing. Also, where possible, pedestrians often use strategies designed to reduce their delay. The environment affects their behaviour, but personal factors are also responsible for variations in behaviour patterns.

Observation of behaviour showed that pedestrians, natural tendencies in crossing the road are often at variance with the behaviour that an IPD would advise.

1) Pedestrians take risks - IPDs would find risky behaviours unacceptable and advise users not to cross in these circumstances.

2) Pedestrians cross unexpectedly - IPDs would find it difficult to reliably predict pedestrians intentions to cross the road from their behaviour. Therefore, users will need to signal their intention to cross to the IPD, or the IPD will have to infer intention to cross from the pedestrian's surrounding environment.

3) Pedestrians change their behaviour during the crossing - IPDs could not know people's intention to change their behaviour. Therefore, users will need to maintain a constant behaviour pattern when crossing the road.

Efficient use of the IPD will involve some users changing the behaviours they would normally use. Many of these behaviours should be changed because they are not safe. However, some safe behaviours will need to be changed so that the IPD can predict the pedestrian's crossing path and calculate safe gaps. Some may respond, but others may not recognise the need, or be willing to accommodate the IPD. Alternative functions for the IPD could encourage social acceptance in other ways, by giving useful information about alternative ways of finding a safe crossing.

PART 4

FURTHER ISSUES OF FEASIBILITY

CHAPTER 10. LEGAL ACCEPTANCE, TECHNOLOGICAL POSSIBILITIES AND COSTS AND BENEFITS OF AN INTELLIGENT PEDESTRIAN DEVICE (IPD)

CHAPTER 10. LEGAL ACCEPTANCE, TECHNOLOGICAL POSSIBILITIES AND COSTS AND BENEFITS OF AN INTELLIGENT PEDESTRIAN DEVICE (IPD)

10.0 INTRODUCTION

Social acceptance of an innovation by individuals is crucial. However, a number of other issues are also relevant. Some of which are discussed briefly in this chapter. They are legal acceptance, technological factors, and economic costs and benefits of an IPD.

Society demands that any innovation conforms to certain legal requirements, especially if it is capable of subjecting users to physical risks. Consumers must be protected, and the possibility of failure may outweigh other considerations in the design stage if the risks include obvious injury or loss of life. This is social acceptance at state level, rather than by individuals, although the two are intimately connected.

This chapter begins by outlining initial investigations into two aspects of the legal acceptance of IPDs: the present legal status of the pedestrian in the road environment in this country and some other countries, and consumer protection and manufacturer's liability in the event of malfunction and consequent injury. The information contained here outlines some of the most important legal issues that may need to be taken into consideration when designing and using IPDs.

The IPD is necessarily a 'high technology' device. It must scan for information from the environment, process it and convey an appropriate response to the user. Section three presents a preliminary investigation of the technological possibilities, and begins by outlining a basic systems operation. Several types of signal transmission medium are briefly assessed on their ability to cope with the amount and quality of information required.

The benefits of developing anything new must be weighed against the costs incurred. It may seem callous to argue that we cannot afford to save human lives (as the IPD has the potential to do) but, our world offers us limited resources and we must make the most efficient use of them by choosing the most cost-effective solutions.

In the fourth section some of the various costs of implementing an IPD are investigated and listed and a crude assessment made of the monetary benefits in terms of a reduction in accidents. These calculations are rudimentary, but give some indication of whether developments could in fact be worthwhile.

Finally, in section five the various strands are drawn together in the form of an overview of the legal, technological and financial feasibility of an Intelligent Pedestrian Device.

10.1 LAWS AFFECTING PEDESTRIAN BEHAVIOUR

Rules control the interactions of drivers and pedestrians, promote orderly behaviour, and hence reduce accident risk. Education informs people of these rules, and enforcement helps ensure conformity. However, enforcement of legislation is often very costly so policy decisions in this area present considerable difficulties (Heraty, 1986).

It is important to understand the present legal status of pedestrians, as using an IPD might affect the rights and obligations that legislation confers. In addition, legislation relating to drivers' interactions with pedestrians might be affected and the legal repercussions may vary from country to country. The following two subsections discuss laws in the United Kingdom and in other countries, respectively, and subsection 10.1.3 outlines the repercussions of these for IPD use.

10.1.1 The United Kingdom

Road traffic legislation places virtually no restrictions on the movements of a pedestrian. There are only two specific restrictions:

- a ban on walking on motorways
- an obligation not to proceed when asked to stop by a police officer controlling traffic.

Apart from this, there is no law in the country to prevent pedestrians crossing the road wherever or whenever they want to. In fact, the right of access to the Queen's Highway is enshrined in common law.

However, access is not the same as precedence: pedestrians in the UK only have precedence when a person given authority by the police e.g. a school crossing attendent stops traffic for them, or at designated crossing places at certain times: on zebra crossings when they step on to the carriageway, and on signal controlled crossings if the signal to cross is in their favour. The legal requirements for pedestrian crossings are given in the following regulations:

- The 'Pelican' Crossings Regulations and General Directions (1987/16)
- The 'Zebra' Pedestrian Crossings Regualations (1971/1524)

New regulations concerning variants of the pelican crossing: the 'puffin' (Dept. of Transport, 1992; 1993a) and 'toucan' crossing (Dept. of Transport, 1993b), are also relevant.

Legislation affecting drivers' behaviour towards pedestrians mostly relates to interactions occurring at pelican, zebra and school crossings. Drivers are advised in the Highway Code to drive carefully near pedestrians, although it is not a criminal offence to do otherwise.

Howarth and Gunn (in Chapman et al., 1982) review the law in relation to pedestrian accidents. Driving offences fall into two categories, those committed intentionally or recklessly and those that are not. Intentional or reckless acts include murder, manslaughter, causing death by reckless driving, reckless driving and non-fatal offences against the person. Spencer's (1985) review of motor vehicles intentionally used as weapons of offence concludes that sentences are much more lenient than had a weapon been used.

In the case of a driver and pedestrian interaction that leads to an injury, civil or criminal proceedings may be brought against a driver for any of the above offences, or for the unintentional offence of careless driving. Proceedings against the pedestrian are very rare, and as such are newsworthy events. Dutta reports in The Times (8/9/94) the case of a nine year old boy who was sued for denting the front wing and headlamp of the car that broke his leg, in an accident that he was allegedly responsible for causing. It seems that, as the insured party, proceedings are most often taken out by the pedestrian against the driver. Indeed, in the above case the boy won £3500 damages for his injuries in a subsequent legal action (Anon, 1995).

The concept of responsibility is at the heart of our legal system. Howarth and Gunn (op cit) argue for a redefinition of responsibility in relation to child pedestrian accidents. They submit that drivers should expect children to act less competently than adults and hence should display more consideration when confronted with a child. If an accident occurs, they suggest that the starting presumption should be that the driver is responsible, and it should be incumbent on the driver to show that he or she is not responsible.

10.1.2 Other Countries

The legal requirements for pedestrians vary from country to country, and in many places (eg. Japan) it is an offence to cross the road away from the recognised crossing points provided (Department of Transport, 1987a). Heraty (1986) reports that in the USA pedestrian legislation is more stringent than in the UK, and 'jaywalking behaviour' is a punishable offence. Other countries may not have legislation now, but the changing road environment may prompt them to introduce it. For example, Heraty notes that a report which reviewed pedestrian safety for the Australian Department of Transport suggested that 'pedestrian behaviour could be regulated by the provision of a code defining where and how pedestrians should cross the road'.

An International Conference on Pedestrian Safety (Hakkert, 1976) included a number of papers that discussed the rights of pedestrians in various different countries. Nussenblatt (1976) outlined pedestrian regulations in Israel. Israeli traffic laws contain a special chapter dealing with the pedestrian, that defines the method of using the footway. There are further regulations stipulating pedestrian behaviour when in an area where vehicles move. Examples of these latter regulations that may be relevant to IPD use are as follows:

> Regulation 108 - No person will walk on the road unless it does not have a sidewalk, proper shoulders or a path allocated to pedestrians.

Regulation 110 - A person will not cross the road without first having inspected the traffic situation and having assured himself that he can cross it safely. If there is a crosswalk, underpass or pedestrian bridge in the vicinity for that purpose, he shall use only these. The pedestrian shall always cross the road with reasonable speed, in a straight and shortest possible line between the edges of the road, and he shall not dwell on the crosswalk while crossing.

Nussenblatt's review of pedestrian accidents concludes that from a juridical aspect all pedestrian accidents have an element of contributory negligence on the part of the pedestrian. Bein (1976) comments that in 'a not inconsiderable number of accidents the fault lies wholly or in part with pedestrians'. Bein also notes that the criminal liability of the pedestrian in Israel has not been enforced, and advocates that 'pedestrians that do not abide by the law applicable to them are criminal offenders no less than drivers who violate the law' and 'it is essential to enforce the law'.

Kraay and Noordzig (1976) conclude that the Dutch regulations pertaining to pedestrians are complicated and confusing, and because they are not enforced are reduced to the "folk crime" category. Similarly, Odendaal (1976) reports that although traffic legislation for pedestrians exists in South Africa, due to non-enforcement, pedestrians tend to ignore them.

The consensus in these studies is that where legislation exists it is not enforced, but with enforcement substantial savings in pedestrian accidents could be made. Heraty (1986) concludes that the 'British police are unenthusiastic about attempting to regulate pedestrian road-crossing behaviour and would not welcome pedestrian legislation (as it) would be virtually unenforceable, due to adverse publicity which would accompany the issuing of "tickets" to otherwise law-abiding citizens, and the absence of an obligation to carry identification in Great Britain'.

10.1.3 Repercussions for IPD Use

In the United Kingdom the restrictions placed on pedestrians should not affect IPD use. There are only two provisos:

- users must ignore advice given by a portable IPD to cross the road if a police officer controlling traffic is requesting them to stop,

- IPDs should not be used on motorways.

The lack of restrictions would allow maximum freedom of movement and safety for IPD users.

Fixed IPDs which work in conjunction with existing facilities (zebra and pelican crossings) could remain subject to the present restrictions on drivers. For pelican crossings that work in conjunction with an IPD, a favourable signal, and hence precedence to cross, would not be given unless it was safe to do so. This might increase pedestrian delay. A red stop light would be given to drivers. If there was no threat to the pedestrian at that time e.g. vehicles had stopped (or were decelerating considerably), the pedestrian would then be told it was safe to cross at that time. If a vehicle then became a threat, by accelerating, that vehicle would have ignored the red stop light. In this case, the driver would be subject to reckless driving legislation. Without impractically high safety margins there will always be a small risk that drivers will act completely unexpectedly and become a threat. Research will be required to ensure that safety margins are set at safe but practical levels.

Similarly, with zebra crossings that work in conjunction with an IPD, a favourable signal would not be given unless it was safe to cross. Again, this might increase pedestrian delay. At zebra crossings, stepping into the carriageway confers precedence to pedestrians. The IPD would need to anticipate whether or not it was safe to cross, and not give a signal to cross if it was not safe. Hence, users would not step into the road unless it is safe to cross. This would mean a change in the regulations. If the IPD signalled the pedestrian to cross and a vehicle became a threat when the pedestrian was crossing, that vehicle would have ignored the zebra crossing regulations. In this case, as with pelican crossings, the driver would be subject to reckless driving legislation.

Adding an IPD to a zebra or pelican crossing need not change the legal situation but it could improve crossing safety. If changes were made to the function of zebra and pelican crossings it would be sensible and legally wise to advise users how these changes might affect them. The present legislation affecting drivers' reckless or careless behaviour would continue to apply to interactions with pedestrians using all types of IPD. However, prosecutions may be reduced with IPD use as users encountering intentional, reckless or careless driver behaviour will normally receive a signal not to cross.

The portable IPD would probably not be legally or ethically acceptable in countries where legislation against 'jaywalking' exists, despite the fact that this legislation does not appear to be enforced. This is because it might be seen as encouraging pedestrians to break the law by giving them advice to cross at undesignated places. In these countries, a portable device could be configured so that it could only be used at designated crossing places, but maximum efficiency would be achieved by making use of gaps on all parts of the road network. Hence, even if legally acceptable, people might not feel the portable IPD had enough uses to make it worthwhile buying. A fixed IPD might be acceptable, and the stand alone model might be particularly useful, with legislation to regulate its operation.

Unenforceable regulations make a mockery of the law. Changing or removing some legislation may be a better option.

10.2 CONSUMER PROTECTION AND MANUFACTURER LIABILITY

Abbott's (1980) investigation into design and product liability discusses a number of issues pertinent to the decision on whether or not a product is safe enough to sell. These include a) the different liability laws in the United Kingdom, Europe and the United States, b) British Standards, and c) reducing design-related hazards.

The Safety Critical Systems Club has held a seminar into the legal and social aspects of safety critical systems, that is, systems in which human safety is of paramount importance. A summary (Anon, 1994) warns that manufacturers and authors of computer software have potential legal liability. Also, the incorporation of a 'black box', to assist post-accident investigations, may become mandatory.

These examples illustrate the emphasis that decision makers have recently given to consumer protection and product liability. Improvements in technology have necessitated legal developments, which are primarily embodied in the United Kingdom in the Consumer

Protection Act, 1987.

Jenkins and Davies' (1989) overview of the Consumer Protection Act in relation to product safety can be summarised thus. Consumer goods, that is, goods which are ordinarily intended for private use or consumption, are subject to criminal controls. In cases where an injury is caused due to the product being defective, users may claim damages, without proving that the producer is negligent. Defective is defined as 'if the safety of the product is not such as persons are generally entitled to expect'. This would affect portable IPDs but not fixed models, because the latter are not intended for private use.

Note that consumers are protected against all purposes for which the product is marketed. Consequently, protection against 'forseeable misuse', that is, what might reasonably be expected to be done with it, is given. For this reason it is important that products are designed and made with their intended and potential uses clearly in mind. Section 10.4 outlines a number of alternative uses for an IPD. Controlling the marketing of these functions and anticipating their possible misuse will be important legal considerations.

To be safe enough, consumer goods must take into account:

- the purpose the goods were marketed for,
- the way the goods are presented for sale,
- the use of marks, like those that indicate independent testing,
- any instructions or warnings for keeping or use of the goods that are supplied with the goods,
- any relevant published standards of safety,
- the existence of any reasonable means for the goods to have been made safer.

Concerning the last of these, the cost, likelihood and extent of any improvement for the goods to be made safer must be taken into account. The legal requirement is for 'reasonable safety', and this may be assessed by carrying out a cost/benefit analysis on any feasible improvement in safety of the standard specifications. This suggests that research and development of standard specifications will need to be comprehensive enough to ensure that all feasible improvements in safety are investigated. For the IPD, which would be a safety related, highly technical innovation on the frontiers of scientific development, this would be very costly.

"Safe" is defined as follows:

> "Safe" in relation to any goods, means that there is no risk, or no risk apart from one reduced to a minimum, that the goods, their keeping, use or consumption, or assembly, etc, will (whether immediately or after a definite or indefinite period) cause the death of, or personal injury to, any person whatsoever.

Two elements of risk are pertinent: the risk associated with the presence of the device, for example if it emitted harmful radiation; and the risk of using the device. The first element is simpler to investigate. The second case suggests that in all forseeable circumstances the risk of crossing with an IPD would need to be below that of crossing without an IPD, and the risk of being involved in an accident would have to be reduced to a "minimum". Since risk levels vary considerably between different sub-groups of the population and at different places on the road environment this may cause some problems in the assessment and setting of acceptable risk levels.

As noted above the Act also covers misuse. Misuse of devices caused by frustration with the equipment because of bad ergonomic design could result in manufacturers being sued. Added psychological pressures imposed by the environment can restrict cognitive and physical abilities and decrease performance levels. These issues need to be considered to increase legal acceptance of the IPD.

The requirement that goods be safe to use and keep also means that the IPD should 'fail safe'. A warning light would be useful to indicate battery depletion or system failure. Also, the IPD should not be capable of putting other road users at risk.

Jenkins and Davies (op.cit) conclude that producers can reduce the chances of being prosecuted or becoming exposed to civil damages claims in a number of ways: for example, third party assessment of products, paying more attention to consumer feedback, and introducing a Product Safety Plan using British Standard 5750 for Quality Assurance proceedures are suggested. Further progress in product safety will now come through improvements in technical standards that are harmonised throughout the European Community.

The role of standards as a means of consumer protection is now recognised. However, Van Weperen (1993) outlines a number of problems in the development of safety standards for consumer products. In the first place there is a low degree of co-operation between countries. Van Weperen claims that 'several safety standards for consumer protection exhibit considerable shortcomings which may serve as obstacles to a satisfactory level of consumer protection'. These problems will complicate the process of legal acceptance for all new consumer goods.

10.3 TECHNOLOGICAL POSSIBILITIES

The following outlines how an IPD might work internally. A brief description of the components is given in terms of the sequence of operations that may be involved, from device activation through to communication with the user. This section also includes some comments on the levels of processing and power required. Then, some of the forms of information gathering medium that could be used are briefly assessed. This section aims to clarify how an IPD could work and whether or not its operation is technologically feasible in the future.

10.3.1 Systems Operation

A diagram that summarises how an IPD might work is shown in figure 29. The four stages occur sequentially, and speed of processing is essential. Box number one represents the first stage in which the transmitter sends out a probe signal and the receiver detects the reflected signal. For some signal mediums the transmitter would detect direct emissions from the environment (eg. light). The transducer shown in the second box then transforms the signal information to digital form which can be processed by a computer.

The intelligent system is represented by the third box. The transformed signal is first pre-processed to remove any 'noise', ie. unwanted signal components caused by stray

Figure 29. The Physical Components of an Intelligent Pedestrian Device.

1 a) TRANSMITTER (depends on medium)
Sends out a probe signal.
b) RECIEVER
Detects reflected signal (or direct emissions from target).

2 TRANSDUCER
Converts signal to digital form

3 INTELLIGENT SYSTEM
Hardware - pre-processes the information to remove 'noise'.
Software - Expert system translates and interprets information to produce a judgement.

4 COMMUNICATION MODULE
Sends a message to the user

radiation, rainstorms or irrelevant objects. An expert system then translates and interprets the information, using algorithms and rules. This is by far the most complex process. It can take some time if the operations in the micro-processor are performed sequentially (parallel processing would speed up the response time.) The intelligent system then decides whether or not it is safe for the user to cross the road.

In the final stage represented in the fourth box, the communication module uses a speech chip to pass the output from the intelligent system to the user. The whole process will need to be completed within a second or the device will be too slow.

The fixed and the portable IPD are likely to require the same basic hardware and follow a similar sequence of operations. For both types, the whole system would be located in one unit. However the level of processing that would be required to operate a portable IPD would be much more complex than that required for a fixed IPD. This is mainly because the fixed IPD would have a fixed frame of reference in which road features were known and vehicle and pedestrian trajectories were much easier to interpret, wheras the portable IPD would not.

At this stage of development it is estimated that the hardware required for all types of IPD would be large and heavy. Such hardware would be acceptable for a fixed IPD as it could be located securely at the site. Portable IPDs require portable hardware and are much further off.

An alternative for both modes would be to build in a small transmitter to pass the incoming signal directly to a remote main-frame computer where the bulk of the processing would be done. This would have at least two advantages: a far more sophisticated system would be possible and a back up system, based on independent information transmitted from vehicles about their position, could be included. The overall response time, however, might increase. Also, the database would need to be constantly updated and would not easily take into consideration transient features like parked cars. Unfortunately, automated road systems are described as being decades away from substantial implementation (Bly et al, 1995).

At complex junctions the device could switch from functioning as a self-contained unit and operate in unison with other on-site equipment, eg. an intelligent system that was processing information from a video recording of the area. This information could then be transferred to the IPD to advise the IPD user whether or not to cross the road, or make use of a fixed facility.

10.3.2 Possible Forms of Signal Medium

Companies developing accident avoidance systems for vehicles are investigating a number of different technologies (Rogers, 1990). Several different forms of signal medium have been assessed on their ability to cope with the amount and quality of information required by an IPD. These are:

a) ultrasonics
b) radio frequency (tag) electromagnetic radiation
c) light (image processing and computer vision)
d) micro wave and radar
e) infra-red

What follows is a summary of the information gathered on these (Narenthran, 1990). However, it should first be noted that in addition to technological feasibility, IPDs would need to be safe for humans. Discussion of this is beyond the scope of this thesis.

<u>a) Ultrasonics</u>

Ultrasonic transducers have a maximum range of 10 metres. In addition, ultrasonic pulses may be hindered by stationary objects between the emitter and the object of interest. For example, the emitter would not be able to detect information about vehicles around a corner. Ultra sound is prone to temperature effects and would not work in the rain as it causes a scattering effect of the signal. For these reasons it appears that an ultrasonic transducer would not be feasible for the main signal medium for an IPD. However, a method of extracting more information from ultrasonic transducers has been developed (Brunfaut et al., 1993). Ultrasonics may be useful to use for measuring pedestrian speeds in order to calibrate the portable IPD for individuals' use (see section 6.2.1).

b) Radio frequency tag

Another possible medium would be a low power UHF radio beam, interacting with an electronic tag attached to the object of interest. An interrogator scans the environment with a beam. When a tag enters the area being scanned by the interrogator it modulates the signal and returns an encoded message. The tag has single chip circuitry. The interrogator detects the modulated reflected signal, which is then decoded to identify the unique tag. The IPD will house the interrogator and each vehicle will need to have a tag attached to it. The interrogator will then register all the vehicles within its range.

Tags have already been used to 'enable moving vehicles to be automatically identified at distances up to nine metres' (Anon, 1993). Tags are small and could easily be incorporated into tax disks on all new cars. However, it would probably take years to ensure that all vehicles were tagged and even then the odd rogue vehicle could cause an accident, which could affect legal acceptance of the device. 'Traps' could remove all such vehicles from the road, but there may be problems with public acceptance of this kind of enforcement.

c) Image processing and computer vision

Computer vision provides scenic analysis by light image. A camera interfaces with a computer that interprets the picture. This can be likened to a human seeing and interpreting his or her environment. Because of its similarity to human cognition this option is appealing. However, the richness of human abilities is not easy to emulate. For example, the scope of our vision would be difficult to capture on camera and interpreting the environment under enormous numbers of different conditions would require an extremely sophisticated intelligent system. Even if it could be built, the equipment would be expensive and bulky. In addition, computer vision would not be able to deal with vehicles of threat that were not visible.

Research in this area is in its infancy. Current research looks promising for the feasibility of IPDs, but experts are sceptical about what can be achieved in the short term.

d) Micro-wave and radar

RAdio Detection And Ranging or RADAR uses the microwave spectrum. It can be used to detect vehicles, and measure distances, speeds and accelerations. However, the equipment is expensive and too large to be portable, although research is underway to produce it in chip form. Radar could not be used to distinguish the richness and detail of the surrounding environment, but it can produce scanned images, and track moving metal.

e) Infra-red

Infra-red could also be used to detect a vehicle's distance, speed and acceleration. However, its range is limited compared with radar. Also, infra-red could not be used to distinguish the richness and detail of the surrounding environment.

In conclusion, the technology for sophisticated portable devices will not be available in the forseeable future. However, hardware for fixed devices could probably be developed in the next few years. Development will be expensive, but it could lead to considerable accident savings. The various costs and benefits of implementing an IPD are discussed in the following section.

10.4 COSTS AND BENEFITS.

'The good and bad effects of new technologies are inextricably bound together in the same object' (Anderson, 1989). For example, motorised transport improves mobility but at a cost to our environment. Good design tries to reduce the risks. However, there will always be knock-on effects. This thesis has discussed the social implications of using IPDs and 'takes a broad overview of the system as a whole and its relation within its environment' (Langley, 1994). The following considers some of the costs and benefits to assess whether or not IPDs are economically feasible.

What is taken into consideration depends on the values we use. Values are often transitory and change according to prevailing opinion. Current ideology favours individuals having choice. The 'different wishes of citizens for different amounts of safety and for different levels of trade-off with price, speed and variety' (Anderson, 1989) are paramount.

It is important to consider wider costs and benefits as early as possible. PACTS (1989) estimated that the social cost of pedestrian casualties was £1 billion per annum and argued that the then £640,000 budget for pedestrian accidents was both indadequate and too small a proportion of the total budget. Including the wider social costs caused by road casualties shows that we could afford to spend much more on developing efficient safety measures.

Some of the more tangible categories of cost and benefit of portable and fixed IPDs are shown in table 30. Each point from the table is highlighted in the discussion that follows.

Mobility is important to us because 'people adopt lifestyles compatible with their level of mobility' (Town 1980). Improving lifestyles or quality of life could be seen as a major benefit of the IPD. As previously discussed mobility benefits include: helping people feel safe, aiding independence training for the mentally retarded, improving or offering mobility to disadvantaged groups and helping children to learn road crossing skills.

Pedestrian delay causes annoyance and risk and is costly. The Department of Transport assigns a value to road users' time for use in economic appraisals (Dept of Transport, 1987c, 1987d). The portable IPD may increase delay by discouraging risky (but quick) crossings. Alternatively for some pedestrians a portable IPD might result in less delay as it may shorten journeys. Also, there may be less **vehicle delay** if pedestrians with portable IPDs wait for a safe gap rather than stop vehicles at a zebra or pelican crossing or make forced crossings. On balance, there is likely to be more pedestrian delay, but crossings will be safer.

There are potential technological **spin-offs**, mainly exploiting the collision aviodance abilities of an IPD; for example, modified versions of an IPD could be used in factories or mines where there may be risk of automated or manually operated mobile machinery colliding with people.

Table 30. *Costs and Benefits of the Portable and Fixed IPDs.*

COSTS	BENEFITS
Research and development	Mobility - feeling safer - aiding the elderly - independence training for the retarded - aiding visually and physically resticted - teaching children road crossing skills
Manufacturing and marketing	
Running costs	
Maintenance	
Delay to pedestrians who don't now make quick, risky crossings	Less vehicle delay due to less pelican and zebra use and forced crossings Less delay for pedestrians who would have gone to a facility
Installation (for fixed modes)	Spin offs: - obstacle detection and collision avoidance in industrial settings
Malfunction	Accident savings

Reducing the number of **accidents** to pedestrians and hence reducing the costs involved will produce the biggest savings involved in IPD use. The Department of Transport publishes road accident statistics and calculates the average cost of accidents annually in Road Accidents Great Britain (Dept. of Transport, 1995a). Calculating these costs is complex and involves making value judgements. For example, how can the worth of a human life be calculated (Adams, 74). The human capital and the willingness to pay approaches have been investigated (Jones-Lee et al., 1985; Dalvi, 1988; Dept of Transport, 1988). But these approaches cannot consider the real overall cost to individuals or society (Consumers Association, 1980). 'The policy issue (of accidents) is mainly one of human casualties, so the question of road safety will always involve a more of less unquantifiable human aspect' (OECD, 1984).

It would be naive to suggest that if everyone had a portable IPD there would be absolutely no accidents involving pedestrians; human errors could still occur at any time. For example, an IPD owner might disregard the machine's advice or the device might malfunction. That said, if a portable IPD were used by the majority of the population, it should be possible to reduce accidents involving pedestrians by an appreciable amount. These would include accidents caused by pedestrians in which the pedestrian him/herself was not a casualty.

The present (1994) financial cost of pedestrian accidents is approximately £2681 million p.a. (Dept. of Transport, 1995a). Against the accident savings we must offset the cost of **research and development** of IPDs, the capital cost of **manufacturing and marketing** them, the **cost of running** them, which includes batteries and **maintenance**, and accidents caused by device **malfunction**.

It is not possible at this stage to estimate what the costs will be. Neither is it certain what proportion of pedestrians might use a portable IPD. However, results from the interviews revealed that 26% of people felt that a portable IPD would be useful for people in general. If 26% usage could be translated to a 10% saving in pedestrian accidents, then that would save £27 millions in one year. Even with high development costs it would seem that if widely used the portable IPD could very quickly become cost-effective.

Manufacturing and running costs should eventually be covered by the consumer. The interviews showed that 60% of respondents said that they would be willing to pay at least £45 for a portable IPD. However, to encourage usage it might be worth subsidising the device, particulary for those in high risk groups, for example, children, because of the large drain on the public purse associated with hospitalisation and loss of output.

9% of pedestrian accidents occur at existing pedestrian crossing facilities. If the fixed IPD associated with a pelican or zebra crossing prevented these accidents there would be a saving of £23 million in one year (Dept of Transport, 1995a). Given that the development costs of this device are likely to be much smaller than those for a portable device, because they operate within a fixed frame of reference, and that the research is likely to be helpful in the development of portable IPDs, it would seem sensible to begin by developing the fixed device.

There are approximately 12,000 pelican crossings (County Surveyors Society, 1994) and 8,000 zebra crossings (Department of Transport estimate given in private communication) that could be fitted with IPDs. This means that pedestrian casualties cost £1,180 per annum per facility. If, after the initial development costs, the manufacturing, **installation** and yearly maintenence costs were less than this, the cost would be recovered in a single year.

10.5 CONCLUSIONS.

Legislation in the United Kingdom does not seem to prevent the use of portable or fixed IPDs. But laws against jaywalking in several other countries would prevent legal use of the portable IPD. Consumer protection and product liability law is extremely complex and will require the expertise of specialist lawyers when prototype devices are available. Nor is the technology ready: problems such as limitation in range, accurate direction of transmitted and/or received signal, identification of relevant stimuli, real time processing and the large size of the necessary hardware are not solvable within the forseeable future for the more sophisticated types of device envisaged here. Researchers into blind mobility have come to the same conclusion. Hardware for fixed devices could probably be developed within the next few years, whereas the future for a portable device is beyond our scope at present.

Non-selective portable IPDs that assess all objects of potential threat to the user, regardless of whether or not they are on the road or the user wishes to cross the road could work with existing technology, given a certain amount of development. This would be a compromise device, with limited functions. It would not give advice about the safety of crossing, so it would not need to 'perceive' the complexity of the road environment; it would simply advise users if they were under threat.

It is important to consider the wider social implications of the IPD in assessing costs and benefits. In spite of the immense difficulties,development of a portable IPD could lead to greater pedestrian mobility as well as saving an enormous amount of money in terms of accident costs. However, at present there are many unknown quantities. Development costs for the fixed IPD are likely to be less, and could form a useful starting point on the way to a fully portable system. Potential accident savings with fixed IPDs associated with pelican and zebra crossings appear to justify spending some money on researching technological possibilities.

PART 5

CONCLUSIONS

CHAPTER 11. SUMMARY AND CONCLUSIONS

CHAPTER 11. CONCLUSIONS

11.0 INTRODUCTION

The aim of this work was to assess the feasibility for a micro-processor based information device, which detects the approach of oncoming vehicles and signals the pedestrian user whether or not a crossing may safely be made. Issues of feasibility were investigated in two main areas as follows: social acceptance, and ergonomic and human factors. Legal implications, technological possibilities and costs and benefits were also briefly reviewed. The aim was to assess the possibilities and limitations in each area, and if possible to develop design criteria.

This chapter begins by summarising the results achieved thus far and then outlines repercussions for the design of the IPD. In addition, limitations of the work and suggestions for further work are made. The final section speculates on the likely future of the IPD.

11.1 SUMMARY

In recent decades there has been little change in the problems pedestrians face in negotiating their surroundings. The IPD could change this pattern, and help vulnerable road users cope with an environment that is becoming increasingly motorised. Roads have often been designed with motorists' rather than pedestrians' convenience in mind. Accident rates show that the road environment is unfriendly to pedestrians, and pedestrians perceive themselves at the bottom of the road user hierarchy. These factors, together with the advance of in-car technology, suggest that pedestrians are becoming marginalised on our roads.

Accidents can be caused by human error, the environment, vehicles or a combination of these, and segregation is currently seen as the best way of avoiding accidents. Although, there is also concern about personal safety on segregated routes. Segregation may be the safest alternative for pedestrians, but it will not affect most of the road network. The IPD could help reduce accidents everywhere, provided people are prepared to use it.

Existing road crossing facilities can involve pedestrians making detours and incurring delays. Portable IPDs might help pedestrians make more efficient use of gaps and reduce delays especially at busy sites: pedestrians would learn that waiting for a safe gap incurs a long delay, and it would be quicker to go to a facility that interrupted vehicular flow to give pedestrians right of way. Adding a fixed IPD to these existing facilities could further improve pedestrian safety and help alleviate the concerns that pedestrians reported about using them.

Other pedestrians could learn from using a portable IPD because it would be a model for safe behaviour. For example, adults who currently accept small safety margins would be made aware of their risk-taking behaviour and children could learn what is an appropriate minimum gap when crossing the road. Children would need to be supervised in this to ensure that they learn road crossing skills, rather than rely solely on the device. Adults might prefer to maintain a risk level above that of the portable IPDs and ignore its advice.

Observations suggested that to reduce delay pedestrians often adapted their behaviour and level of risk taking, e.g. by making angled crossings. Basic IPDs, of the type envisaged, would not take angled crossings into account. Other behaviours observed, for example, changes in walking speed mid-crossing and accepting smaller safety margins, would require a facility in sophisticated IPDs to trigger a warning where necessary. In approximately half of the crossings observed there was no traffic in the immediate vicinity. Of the remainder, approximately half crossed with a reasonable safety margin. But even in this limited study some people took considerable risk, and pedestrians increased their speed to make use of smaller gaps and reduce delays. These results suggest that people will need to adapt their behaviour when using an IPD, and the more basic the IPD the more they will need to adapt.

It seemed from the interviews that most pedestrians feel in control of the road environment and this may lead to them being unrealistically optimistic about their abilities. Conversely, in some circumstances, pedestrians were shown to abdicate responsibility for their safe crossing. Also, they may abdicate responsibility by consciously or subconsciously assuming that motorists will take avoiding action. The illusion of control may be one reason why pedestrians are sceptical about the need for an IPD.

Acceptance of what was seen as a novel device appeared to depend on perceived road crossing abilities and needs. Children felt it would help them, but their parents and adults did not agree. It seemed they thought it would prevent their children from developing the strong sense of self-control they believed they had themselves. The IPD was thought most useful for people with some kind of mobility handicap, that is, for people who are not in control of the road environment. The visually restricted appear to have perceived it as visual sense replacement, enabling mobility rather than as a safety aid; the elderly seemed to have seen it as a 'top up' to their failing abilities, and the adults agreed with this. Crossing facilities for pedestrians with mobility problems are inadequate. IPDs could increase freedom of movement for many of these people by giving them the extra confidence they need, both at existing facilities and at self-selected points on the road network.

Experience affects attitude, and perhaps interviewees' initial perceptions of the IPD would change with more information and experience. A large proportion of people said that it might be useful, suggesting that they were not yet sure of its functions. The majority of people said that it would or could be useful, and 26% said that it would definitely be useful for people in general.

Experience suggests that marketing can vastly improve social acceptance and the interviews suggested a number of marketing strategies for different groups of pedestrians. Also, there are open-minded types of people who readily buy and use innovations and thereby act as models for other people. It would be wise not to market the device as an aid for the disabled if the target is the whole community, because this may reinforce the preconception that the device is an aid for disabled people. Some disabled people are likely to require additional functions, for example, visually impaired pedestrians would require help with orientation.

The IPD must be considered carefully to assess whether it can be integrated into our culture with minimal social cost. This will involve assessing alternative strategies for reducing pedestrian accidents. Integrating any innovation into the culture will involve acquiring and changing attitudes.

The present level of technological knowledge makes development of a portable IPD within the next few years unlikely. Whilst the concept of an IPD appears to be legally acceptable in the United Kingdom, the reliability requirements implied by the Consumer Protection Acts would increase the already considerable research and development costs. Large research budgets could shorten development lead times. However, at this stage there are still a number of unknowns that make it difficult to assess whether or not it is worth the injection of cash. Assessing costs and benefits depends on the value systems we use. Present Government values estimate pedestrian accidents at £2681 million per annum.

Even though the portable IPD is likely to have greater social benefit than the fixed IPD, it would probably be better to concentrate efforts into developing fixed modes. The fixed IPD was perceived as similar to existing facilities as it is a public rather than private aid. Some people perceived it favourably and there appeared to be no legal complications. It should be quicker to develop the technology for fixed IPDs, they will assist in the development of the portable IPD and still save up to £23 million per annum in the cost of accidents.

11.2 MODELS AND MODES OF IPD

A basic outline of some types of fixed and portable IPD was given in section 1.1. This section summarises the results in terms of design criteria for a portable IPD. Different types of IPD will have different functions and levels of sophistication. What follows is an outline of some fundamental design criteria that would probably be relevant to all models and modes of portable IPD. Following this an outline of the design criteria for a) a basic model and b) a sophisticated portable IPD are given, and some suggestions for alternative functions are made.

In all cases, speed of processing is paramount as the IPD will need to work in real time. Also, the method of operation will need to be simple so that the cognitive load on users is not increased to an unmanageable level, and there will be no requirement for training. The number and type of messages given to users will need to be carefully worked out depending on the functions of that mode of IPD. For example, different sounds could be used to indicate that it was safe or unsafe to cross at that time. Sounds would be better than verbal instructions because words need to be quite loud to be heard. An earpiece could be used to reduce the level of noise, or a volume control would allow users a choice of volume. A noisy, bulky or otherwise obtrusive IPD would make users conspicuous. Preferably, IPDs would be small and easy to carry around, like a wrist watch or pendant. However, it may be necessary for it to be exposed as some forms of radiation source will not work if they are obscured.

The following lists basic and more sophisticated design criteria for an IPD. A more basic device that could be a useful precursor to the IPD would have a single function; to give a warning to users that they were approaching a road. This would help prevent accidents caused by pedestrians crossing without thinking. Alternatively, a basic device could simply give warning to users if they were under threat from any object in the environment.

DESIGN CRITERIA FOR A BASIC IPD

- pedestrian must choose an appropriate place to cross e.g. with visibility and not near any kind of junction
- IPD cannot be used with a central refuge
- pedestrian must stand on the kerb
- pedestrian must not move along the kerb
- pedestrian must request information from the IPD about the safety of crossing
- after being requested for information, the IPD signals that it is safe or it is not safe until the device is deactivated (usually at the end of the crossing)
- pedestrian must make an approximate 90 degree crossing
- pedestrian must use the same walking speed as s/he used when the IPD was calibrated (e.g. at the beginning of the trip)
- pedestrian must cross using a constant walking speed
- if for any reason it becomes unsafe during a crossing e.g. the user stops in the road, the IPD gives a warning signal

- a fail safe mechanism operates if the device fails

DESIGN CRITERIA FOR A SOPHISTICATED IPD.

- IPD recognises that the pedestrian intends to cross the road (if it is unsure of the pedestrian's intended movement it signals the user)
- pedestrian can cross the road anywhere
- IPD can be used with a central refuge
- pedestrian can walk into the road e.g. by a parked car before starting to cross
- pedestrian may move along the kerb before starting to cross
- IPD only signals if it is not safe to cross the road
- pedestrian can make angled crossings provided s/he orientates her/himself to the intended angle
- pedestrian must use the same walking speed as s/he used on the pavement previously (IPD is calibrated to walking speed continually)
- pedestrian must cross using a constant walking speed
- if for any reason it becomes unsafe during a crossing e.g.. the user stops in the road, the IPD gives a warning signal
- a fail safe mechanism operates if the device fails

SOME ALTERNATIVE FUNCTIONS.

- IPD increases the volume of the signal if the user is threatened by an approaching vehicle.
- addition of an unsure signal between safe and unsafe
- IPD advises the user if the crossing place selected is too complex for it to cope with
- if the conditions demand e.g. high vehicle flow, the IPD advises users to find another crossing place or time, or gives the location of the nearest crossing facility
- IPD gives a choice of safety margin settings
- IPD can be adjusted for use with pushchairs, prams, bicycles, foreign visitors.
- for the visually restricted the IPD can:
    - locate the kerb

  - detects veering mid crossing
  - detect and advise on the position of obstacles
- for the aurally impaired the IPD has:
  - a visual or tactile indicator

Even the basic single function IPD would require a considerable amount of intelligence. The technology for the sophisticated version will not be available for many years and will probably involve computer vision. What can be achieved will depend largely on how intelligent systems and technology develop.

11.3 LIMITATIONS OF THE WORK AND SUGGESTIONS FOR FURTHER WORK

As work on the feasibility of IPDs is in its infancy there is tremendous scope for further work. What follows is an overview of the most important areas for further research.

The problems pedestrians face in the present and likely future road environment were discussed in relation to IPD use. There were two main limitations of this work. Firstly, only the road environment in Great Britain was discussed, so further research on other countries and cultures will be required, although it is anticipated that there will be a great many similarities between Western industrialised countries. Secondly, political issues that surround how we manage our environment and the road infra-structure were not included. This is an important topic worthy of further debate as it will be helpful in deciding which technological changes are desirable.

Pedestrian detours and delays could be minimised by using a portable IPD. A study of the detours and delays avoided and endured using a portable IPD (perhaps employing a simulation model), would help ascertain what level of time-saving benefit might be expected. Also, it would be useful to find out if there will be changes in the amount, the type and the routes of trips that would be made with IPDs, and to assess the affect of vehicle movements on pedestrian behaviour.

The interviews on social acceptance produced some interesting results. Social acceptance is difficult to assess at feasibility stage as some impacts of innovations are not apparent until implemented widely. For example, we can only guess the possible affects on those who cannot afford, or choose not to use, a portable IPD.

Results suggested that most pedestrians do not see themselves as being threatened by the road environment. In future work on social acceptance it may be useful to assess whether or not knowledge about the risk of road travel would increase IPD use, and what kinds of education and marketing would improve usage. Also, it would be useful to research the effects of IPDs on risk assessment.

The observational research on pedestrian behaviour achieved some interesting results, despite the rudimentary data collection (discussed in section 9.8). A limited selection of sites was used so further work could concentrate on different types of road environment, including those that are more complex for pedestrians to cross. Also, more data on child and elderly people's crossings would help confirm some tentative hypotheses made in this work, for example, that elderly people have a smaller second-leg safety margin then other age groups.

Several differences in behaviour on the first and second leg of crossing were observed, and pedestrians often made finely balanced judgements on the second leg of crossing. More data on rejected gaps and lags might help discover the smallest ones that are acceptable. It was found that the gaps accepted depended heavily on the pedestrians' crossing speeds. Further research to assess any differences between footway and crossing speed would be useful to discover how walking speed is used to mediate between the gaps accepted. The case-study method might produce more useful information about this. Shadowing volunteer subjects on the trips they make would help analyse the problems pedestrians face every day, and show the number and type of crossing movements made that could be assisted by an IPD, and the circumstances of crossing that would preclude IPD use.

Finally, a considerable amount of further work on legal acceptance, costs and benefits and technological feasibility is required. For example, is still not clear which signal transmission medium will be best. Research into several of them is currently being carried out for other purposes. Hence, advances in the technological feasibility of IPDs may be made through other research, e.g. in-vehicle collision avoidance. At this stage, it is probably best to concentrate research efforts into developing technology.

11.4 THE FUTURE FOR THE IPD

It will be some time before artificial intelligence can match peoples' ability to perceive the road environment and to learn from experience. The technology for a portable IPD is not yet ready and development problems are not solvable within the foreseeable future. Hardware for fixed devices could probably be developed within the next few years, and development costs are likely to be less. The fixed device could form a useful starting point on the way to a fully portable system and potential accident savings appear to justify further research.

The potential conflict between pedestrians and motor vehicles is likely to remain a problem for a considerable time. Bly et al (1995) have emphasised the range of 'future scenarios for inland surface transport' (see section 2.3). Provisions for pedestrians will be made, but they are likely to follow whatever advances are made for vehicular transport. The road environment of the future will play a large role in determining whether or not people feel the need for an IPD. If a portable IPD helps pedestrians satisfy their individual needs in that environment they will buy one, and it will be socially acceptable. The culture of safety will also play a role in whether or not people feel they need an IPD.

Government could improve pedestrian safety considerably by endorsing fixed types of IPD. However, they will only do this if they are cost effective. Use of the portable IPD is a matter for individual choice, but if Government encourages the view that the IPD has a place in the road environment of the future then this support will be a useful first step.

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APPENDICES.

1 Bubble Drawing Used in the Group Interview.

2 Ranking Task Form Used in the Group Interview.

3 Follow-up Questionnaire Given After the Group Interview.

4 Interview Schedule for the Pilot Study with Adults.

5 Form for Recording Pedestrians' Road Use in the Group Interviews.

6 Interview Schedule for the Pilot Study with Children.

7 Advertisement Used to Recruit Interviewees.

8 Line Drawing Artist's Impression of a Fixed Stand Alone Intelligent Pedestrian Device.

9 Written Description of a Portable, Active, Non-Selective Intelligent Pedestrian Device (for Adults).

10 Written Description of a Portable, Active, Non-Selective Intelligent Pedestrian Device (for Children).

11 Written Description of a Fixed, Stand-Alone, Passive, Selective Intelligent Pedestrian Device for Adults).

12 Written Description of a Fixed, Stand-Alone, Passive, Selective Intelligent Pedestrian Device (for Children).

13 Picture of a Model of a Portable Intelligent Pedestrian Device.

14 Schedule of the Interview with Adults.

15 Schedule of the Interview with Children.

16 Tables of the Mean Rank, Rank of Mean Rank and Range of Rankings for Each of the Five Interviewed.

A = Adults age 18-60
B= Adults age 65+
C = Visually Restricted
D = Parents of Children Age 5-9
E = Children Age 10-14

17 Rankings and Interview Results for Nine Pedestrian Facilities.

18 Descriptions of the Projective Drawings of 'Something to Help You Cross the Road' for the

Younger and Middle Age Band Groups of Children, and Verbal Descriptions Given by the Oldest Group.

19 Stories Told About the Projective Drawings of 'A Child Out One Day With a Portable IPD' for the Youngest and Middle Age Band Groups of Children, and Verbal Descriptions of a Portable IPD Given by the Oldest Group.

20 Tables of the Negative, Neutral and Positive Bubble Drawing Comments Made by the Adult, Elderly, Parent and Child Sub-Samples.

A = Adults
B = Elderly 65+
C = Parents
D = Children

21 Number of Interviewee in Each Sub-Sample Reporting Different Lowest Acceptable Percentages of Accuracy for a Portable IPD in the Follow-up Questionnaire.

22 Kruskal-Wallis Z Values for Each Sub-Sample's Rankings of the Portable IPD on the Scales of Perceived Safety and Like of Use.

23 The Percentage of Respondents in the Adult, Elderly, Visually Restricted and Parent Sub-Samples that Answered Yes, Perhaps and No When Asked if the Portable IPD Might be Useful to Various Groups of Pedestrians in the Follow-up Questionnaire.

24 Differences Between the Adult, Elderly, Visually Restricted and Parent Sub-Samples in the Assessment of the Portable IPD for the Six Groups Assessed: Kruskal-Wallis H Values with the Corresponding Z Values and the Level of Significance.

25 Differences in the Assessment of Usefulness of the Portable IPD for the Self, Elderly, Children, Visually Restricted, Physically Restricted and People in General Groups: Friedman Test Estimated Means and Sum of Ranks.

26 Kruskal-Wallis Z Values for Each Sub-Sample's Ranking of the Fixed IPD on the Scales of Perceived Safety and Like of Use.

27 Data Collected on Pedestrian Crossing Movements from the Video Observations.

28 The Amount of Data Collected at Each Site in the Observational Study of Pedestrian Crossing Movements.

29 Vehicle Flow, Pedestrian Flow and Pedestrian Crossing Flow: Minimum, Maximum, Mean and Flow Indices for Each Site and Day.

30 Minimum, Maximum and Mean Number of Kerb/Road Wait Times for Each Site and for all Sites Together and the Midway Wait Times for all Sites.

31 Number and Percentage of Pedestrians Crossing the First and Second Leg of the Road

Using Various Categories of Crossing Angle.

32 The Minimum, Maximum and Mean Number of Observations of Time to Midway, Second Leg Crossing Time, Total Unbroken Crossing Time and Crossing Speeds in Metres per Second for Each Site and for All Sites.

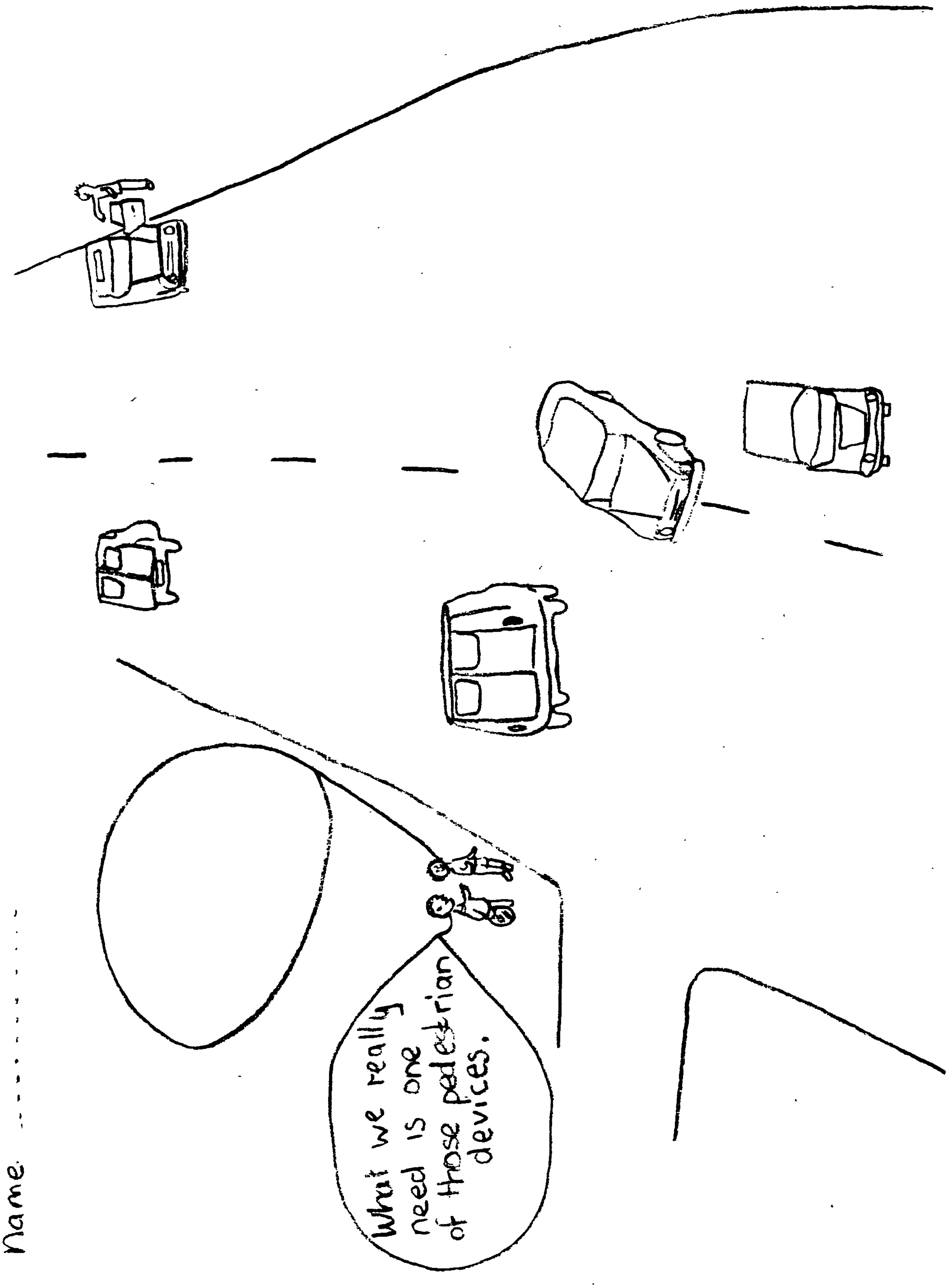
33 The Minimum, Maximum and Mean Number of Observations for the Downstream Speed and the Crossing Place Speed of Vehicles that Interacted with Pedestrians for Both Legs of Crossing Combined at Each Site and for all Sites.

34 The Minimum, Maximum and Mean Number of Observations of Gaps Accepted and Safety Margins for Both Legs of Crossing, for each Site and for all Sites.

35 Number of Observations, Mean Gap Accepted and Safety Margin for Both Legs of Crossing, for each Age and Sex Group.

36 Results of the Regression Analysis for First and Second Leg Gap Accepted.

APPENDIX 1. BUBBLE DRAWING USED IN THE GROUP INTERVIEW.



APPENDIX 2. RANKING TASK FORM USED IN THE GROUP INTERVIEW.

Name..............................

Please <u>rank order</u> the following list of pedestrian facilities on the scale:

1 = most safe ------ 9 = least safe

	RANK
ZEBRA CROSSING	_____
FOOTBRIDGE	_____
FIXED IPD	_____
PELICAN CROSSING	_____
REFUGE	_____
SCHOOL CROSSING	_____
PORTABLE IPD	_____
SUBWAY	_____
PEDESTRIANISED ST.	_____

Putting the numbers to the right of those you have already written, please now <u>rank order</u> the list of pedestrian facilities on the scale:

1 = like using most ---- 9 = like using least

APPENDIX 3. FOLLOW-UP QUESTIONNAIRE GIVEN AFTER THE GROUP INTERVIEW.

Dear Interviewee,

Now that you have had the chance to think about what it might be like crossing roads with a portable Intelligent Pedestrian Device, I would be obliged if you would answer the following questions and return this letter to me using the enclosed pre-paid postage label.

May I take this chance to thank you for being an interviewee and for completing and returning this form.

1/ Do you think a portable Intelligent Pedestrian Device would be useful to any of the following people? (Please tick the appropriate boxes.)

	No	Yes	Perhaps
yourself	[ ]	[ ]	[ ]
an elderly person	[ ]	[ ]	[ ]
a child over ten years old	[ ]	[ ]	[ ]
a visually hadicapped person	[ ]	[ ]	[ ]
a physically handicapped person	[ ]	[ ]	[ ]
people in general	[ ]	[ ]	[ ]
other (please specify).............	[ ]	[ ]	[ ]

If you have answered yes or perhaps to any of the above, please answer the next two questions. If you have answered no to <u>all</u> of the above, then please finish by filling in your name in the space provided at the bottom of this page.

2/ What level of accuracy for a portable Intelligent Pedestrian Device do you think is acceptable? (Please ring the <u>lowest</u> level acceptable.)

90% 95% 99% 99.99% 100%

3/ How much would you be prepared to pay for a portable Intelligent Pedestrian Device? (Please ring the <u>largest</u> amount you would be prepared to pay.)

£5 £15 £45 £135 £400

Comments:

NAME...GROUP.....

APPENDIX 4. INTERVIEW SCHEDULE FOR THE PILOT STUDY WITH ADULTS.

PILOT STUDY INTERVIEWS - Procedure for Adults.

Where methods or techniques have already been described the appropriate section is referenced. Parts of the interview that are not questions put by the interviewee are in capitals.

1/ INTRODUCTION - details concerning the content of the interview are given and any questions are answered. Familiarisation with the video recording equipment.

2/ NAME BADGES - are filled in and put on.

3/ RECORD OF APPROXIMATE ROAD USE FORM is completed - (See section 4.5 and appendix 5) Each member of the group introduces themself and outlines the details from their form.

4/ Non directive questions - related to the problems of being a pedestrian. (See section 4.1.1).

a/ What do you think we mean by the term ' a pedestrian'?
b/ What do you like about being a pedestrian?
c/ What do you dislike about being a pedestrian?
d/ Do you think pedestrians face any particular problems?
e/ Do you think pedestrians face any particular problems on the road environment?

5/ Critical incident questions - related to near misses and accidents crossing the road. (See section 4.1.1).

a/ Why do you think pedestrians get run over?
b/ In general, whose fault do you think pedestrian accidents are?
c/ What sort of people do you think become pedestrian casualties?
d/ How do you think we could avoid pedestrians being run over?

6/ Focused questions - about pedestrian facilities and the IPD.

(See section 4.1.3).

- a/ What do you think of the facilities available for pedestrians?
- b/ Which facilities do you think are the safest and why?
- c/ Do you think any other arrangements or facilities should be made for pedestrians?
- d/ What would be your ideal solution to the problems pedestrians face: given our present situation (the road environment as it is), if you could have whatever help you wanted to cross the road what would it be?
- e/ What would you think about a device that was held by you, that told you whether or not it was safe to cross the road?

7/ Focused questions - about IPDs.

a/ VERBAL DESCRIPTION GIVEN AND ARTIST'S IMPRESSION SHOWN OF A FIXED PASSIVE SELECTIVE STAND ALONE IPD.

- i/ Do you think people would find it useful?
- ii/ Do you think people would use it?
- iii/ Would you use it?

b/ VERBAL DESCRIPTION GIVEN AND MODEL SHOWN OF A PORTABLE ACTIVE NON-SELECTIVE IPD.

- i/ BUBBLE DRAWING GIVEN. (See section 4.1.4 and appendix 1)
- ii/ Do you think people would find it useful?
- iii/ Do you think people would trust it?
- iv/ Do you think people would buy it?
- v/ Would you buy it for
  - I/ Yourself.
  - II/ An elderly relative.
  - III/ A child relative.
  - IV/ Someone blind / handicapped
  - V/ Anyone else.

8/ RANKING TASK FORM - (See section 4.2.1 and appendix 2).

9/ DEBRIEFING - Any queries, questions or comments.

APPENDIX 5. FORM FOR RECORDING PEDESTRIANS' ROAD USE IN THE GROUP INTERVIEW.

RECORD OF APPROXIMATE ROAD USE. **NAME............................**
AGE..........

Please answer the following questions by ticking the appropriate boxes.

1/ On the whole, the traffic within half a mile of my home is:

light [ ] medium [ ] heavy [ ]

2/ When I go out, I nearly always have to cross a heavily trafficked main road.

	Y	N
	[ ]	[ ]

3/ How much do you walk?

[ ] as little as possible
[ ] an average of less than 1 mile per day
[ ] an average of more than 1 mile per day

	Y	N
4/ Are you a bicycle user?	[ ]	[ ]
5/ Are you a motor cycle user?	[ ]	[ ]
6/ Do you use, and have a full license for any other type of motor vehicle?	[ ]	[ ]

a/ How may miles per year do you drive?

[ ] less than 4,000 miles
[ ] between 4,000 - 12,000 miles
[ ] more than 12,000 miles

APPENDIX 6. INTERVIEW SCHEDULE FOR THE PILOT STUDY WITH CHILDREN.

PILOT STUDY INTERVIEW - Procedure for Children.

Where methods or techniques have already been described, the appropriate section is referenced. Parts of the interview that are not questions put by the interviewee are in capitals.

1/ INTRODUCTION - details concerning the content of the interview are given and any questions are answered. Familiarisation with the video recording equipment.

2/ NAME BADGES - are filled in and put on. Ages are given.

3/ RECORD OF APPROXIMATE ROAD USE IS COLLECTED - Children respond to questions by putting their hands up and making additional comments.

a/ Do you have a car in your family?
b/ Do you have a bicycle? Do you use it a lot?
c/ How much walking do you do - to school, to the local shops, go for a walk, take dog out.
d/ Where can you go on your own - own road, to school, to the local shops, on buses to the town centre (Enfield).

4/ Non directive questions - related to the problems of being a pedestrian. (See section 4.1.1).

a/ What do you like about walking?
b/ What don't you like about walking?

5/ Critical incident questions - related to near misses and accidents crossing the road. (See section 4.1.2).

a/ Has anyone seen or been in an accident or near accident? If not make one up.
b/ DRAW A PICTURE OF THE SITUATION - each child explains their picture.

6/ Focused questions - about pedestrian facilities. (See section 4.1.3).

a/ How can you get accross the road?
b/ What help can you get crossing the road?
c/ Which help do you like?
d/ Which help don't you like?
e/ If you could have **anything** to help you cross the road what would you want?
f/ DRAW A PICTURE OF IT - each child explains their picture.

7/ Focused questions - about the portable IPD.

a/ What about a machine/device that you carried around with you that told you whether or not it was safe to cross the road. What do you think it would be like?
b/ DRAW A PICTURE OF IT - each child explains their picture.
c/ SIMPLE VERBAL DESCRIPTION GIVEN AND MODEL SHOWN OF A PORTABLE ACTIVE NON-SELECTIVE IPD.

i/ DRAW A PICTURE AND/OR MAKE UP A STORY OF A CHILD OUT ONE DAY WITH THIS DEVICE. - each child explains their picture, and
ii/ What will happen next? and
iii/ What happened before?

8/ Comparison of other pedestrian facilities and the IPD - (See secion 4.2.1).

a/ Other than the IPD what other things can help you cross the road?
b/ SHOW THREE PEDESTRIAN FACILITIES, EACH WRITTEN ON A SMALL PIECE OF PAPER.

i/ Tell me how two of them are similar and one is different.

c/ REPEAT b/ several times.
d/ RANKING TASK FORM - (See section 4.2.1 and appendix 2).

9/ Further focused questions - about the portable IPD.

a/ Would you like one? Why?
b/ When would you use one?
c/ Would you trust it?

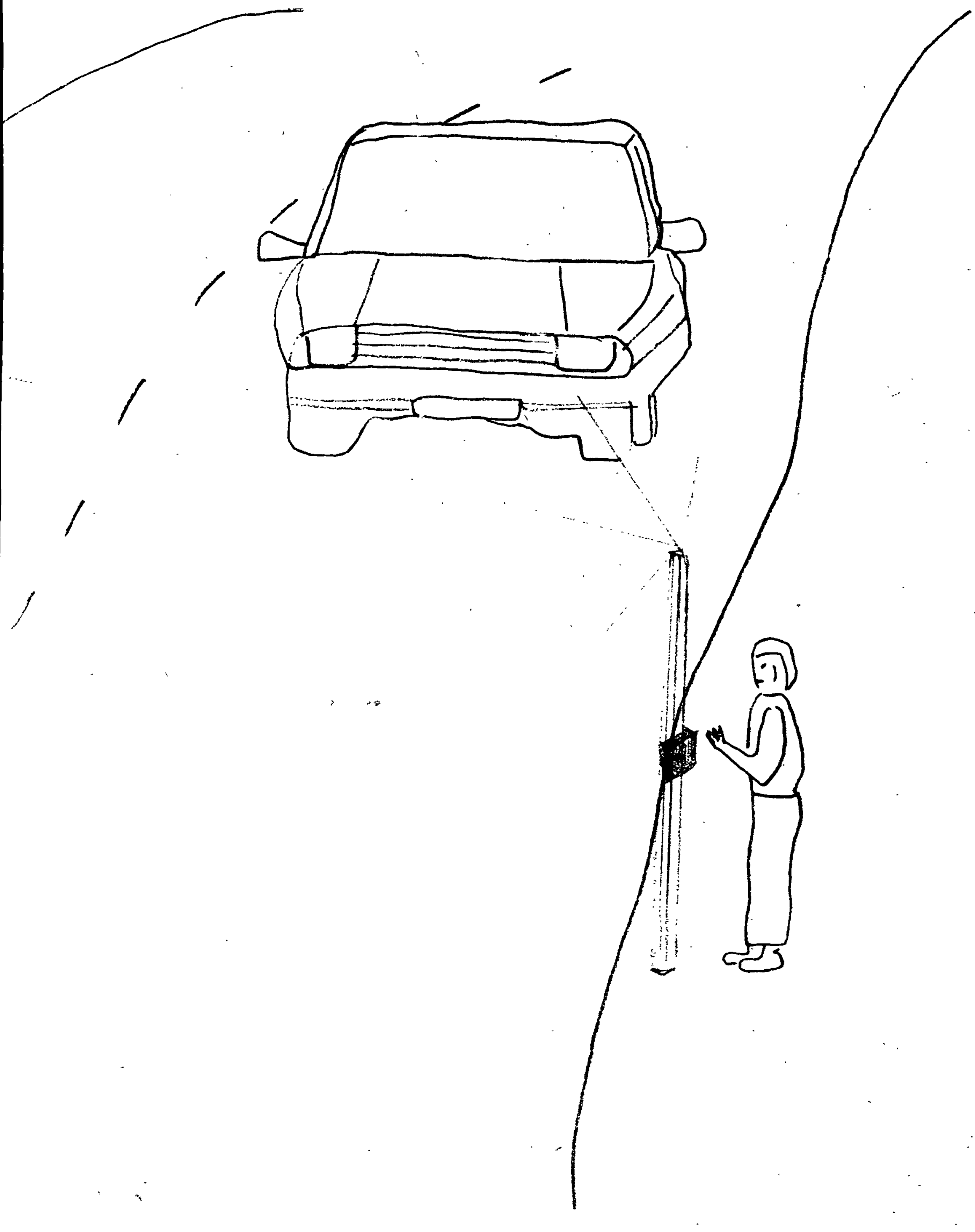
10/ DEBRIEFING - Any queries, questions or comments.

APPENDIX 7. ADVERTISMENT USED TO RECRUIT INTERVIEWEES.

Middlesex Polytechnic require people to be interviewed, day or evening about the problems of being a pedestrian.
Payment of £5 for a once only 1 1/2 hour session
Phone Ms P Armsby
368 1299 ex 7378

PEOPLE required to be interviewed aged 18-60 by Middlesex Polytechnic, daytime or evening, about the problems of being a pedestrian. Payment £5 for a once only 1½ hour session. Ring Ms Armsby 368 1299 extn 7378W

APPENDIX 8. LINE DRAWING ARTIST'S IMPRESSION OF A FIXED STAND ALONE INTELLIGENT PEDESTRIAN DEVICE.



APPENDIX 9. WRITTEN DESCRIPTION OF A PORTABLE, ACTIVE, NON-SELECTIVE INTELLIGENT PEDESTRIAN DEVICE (FOR ADULTS)

An Intelligent Pedestrian Device (IPD) is a device that monitors the vehicles on the road to assess whether or not it is safe for the pedestrian using the device to cross the road. It then tells the pedestrian whether or not to cross.

This type of IPD is portable, that is, a person would carry their own personal IPD around with them. This device would be active or working all the time so that whenever a vehicle was of threat to the person carrying the device it would warn them. Its main function would be to give the carrier advice about whether or not it was safe to cross the road, although it would also tell the user if a vehicle anywhere within range was of threat to the carrier.

APPENDIX 10. WRITTEN DESCRIPTION OF A PORTABLE, ACTIVE, NON-SELECTIVE INTELLIGENT PEDESTRIAN DEVICE (FOR CHILDREN)

An Intelligent Pedestrian Device (IPD) is a device that monitors the vehicles on the road to assess whether or not it is safe for the pedestrian using the device to cross the road. It then tells the pedestrian whether or not to cross.

This type of IPD would be at a fixed location, that is, it would be permanently situated on the pavement by the roadside. To activate the device users would have to press a button. The device would then scan all the vehicles on the road. If it was safe to cross it would tell the user to cross, if it was not safe at that time it would keep telling the user not to cross until it was safe to cross. It is different from a pelican crossing because there are no traffic lights to stop vehicles, and the device assesses whether it is safe or not.

APPENDIX 11. WRITTEN DESCRIPTION OF A FIXED STAND-ALONE PASSIVE SELECTIVE INTELLIGENT PEDESTRIAN DEVICE (FOR ADULTS)

This device checks the traffic to see if it is safe to cross the road. It then tells the person using it whether or not it is safe to cross.

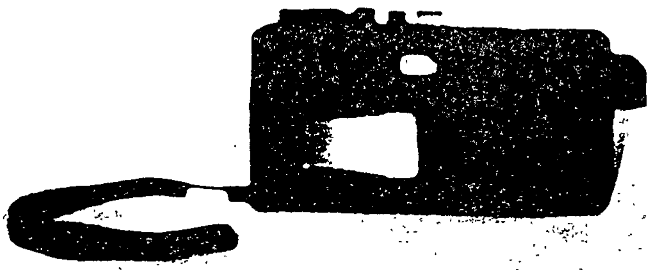
This type of device is carried round by the person using it. When the person carrying it reaches the roadside it would automatically tell them whether or not it was safe to cross the road. Also, if a vehicle was coming towards the person with the device, it would warn them.

APPENDIX 12. WRITTEN DESCRIPTION OF A FIXED STAND-ALONE PASSIVE SELECTIVE INTELLIGENT PEDESTRIAN DEVICE (FOR CHILDREN)

This device checks the traffic to see if it is safe to cross the road. It then tells the person using it whether or not it is safe to cross.

This type of device is fixed at a certain place on the pavement by the road side. To use it a person must press a button and the device would then tell them whether or not it was clear to cross. It has no traffic lights to stop vehicles. It tells its user if there is a safe gap to cross in.

APPENDIX 13 PICTURE OF A MODEL OF A PORTABLE INTELLIGENT PEDESTRIAN DEVICE.



APPENDIX 14. SCHEDULE OF THE INTERVIEW WITH ADULTS.

INTERVIEW SCHEDULE - Basic Procedure for Adults.

Where methods or techniques have already been described the appropriate section is referenced. Parts of the interview that are not questions put by the interviewee are in capitals.

1/ INTRODUCTION - details concerning the content of the interview are given and any questions are answered. Familiarisation with the video recording equipment.

2/ NAME BADGES - are filled in and put on.

3/ RECORD OF APPROXIMATE ROAD USE FORM is completed - (See section 4.5 and appendix 5) Each member of the group introduces themself and outlines the details from their form.

4/ Non directive questions - related to the problems of being a pedestrian. (See section 4.1.2).

a/ What do you like about being a pedestrian?
b/ What do you dislike about being a pedestrian?
c/ Do you think pedestrians face any particular problems?

5/ Critical incident questions - related to near misses and accidents crossing the road. (See section 4.1.2).

a/ Have any of you ever been involved in a pedestrian accident/near miss.
b/ Why do you think pedestrians get run over?
c/ In general, whose fault do you think pedestrian accidents are?
d/ What sort of people do you think become pedestrian casualties?
e/ How do you think we could avoid pedestrians being run over?

6/ Focused questions - about pedestrian facilities and the IPD. (See section 4.1.3).

a/ What do you think of the facilities available for pedestrians?
b/ Which facilities do you think are the safest and why?
c/ Do you think any other arrangements or facilities should be made for pedestrians?
d/ What would be your ideal solution to the problems pedestrians face: given our present situation (the road environment as it is), if you could have whatever help you wanted to cross the road what would it be?
e/ What would you think about a device that was held by you, that told you whether or not it was safe to cross the road?

7/ Focused questions - about IPDs.

a/ VERBAL DESCRIPTION GIVEN AND MODEL SHOWN OF A PORTABLE ACTIVE NON-SELECTIVE IPD. (See appendix 9 and 13).

i/ BUBBLE DRAWING GIVEN. (See section 4.1.4 and appendix 1)
ii/ Do you think people would find it useful?
iii/ Do you think people would trust it?
iv/ Do you think people would ~~buy it?~~
v/ How much would you pay for it?
vi/ How accurate/reliable would it have to be?

b/ VERBAL DESCRIPTION GIVEN AND ARTIST'S IMPRESSION SHOWN OF A FIXED PASSIVE SELECTIVE STAND ALONE IPD. (See appendix 11 and 8)

i/ Do you think people would find it useful?
ii/ Do you think people would use it?
iii/ Would you use it?

c/ Going back to a portable IPD, please raise your hand if you would you buy it for:

I/ Yourself.
II/ An elderly relative.
III/ A child relative.
IV/ Someone blind/handicapped.
V/ Anyone else.

8/ RANKING TASK FORM - (See section 4.2.1 and appendix 2).

9/ DEBRIEFING - Any queries, questions or comments. Hand out and explain follow-up questionnaires. (See section 4.2.2). Pay and thank participants.

APPENDIX 15. SCHEDULE OF THE INTERVIEW WITH CHILDREN.

INTERVIEW SCHEDULE - Basic Procedure for Children.

Where methods or techniques have already been described, the appropriate section is referenced. Parts of the interview that are not questions put by the interviewee are in capitals.

1/ INTRODUCTION - details concerning the content of the interview are given and any questions are answered. Familiarisation with the video recording equipment.

2/ NAME BADGES - are filled in and put on. Ages are given.

3/ RECORD OF APPROXIMATE ROAD USE IS COLLECTED - Children respond to questions by putting their hands up and making additional comments.

a/ Do you have a car in your family?
b/ Do you have a bicycle? Do you use it a lot?
c/ How much walking do you do - to school, to the local shops, go for a walk, take dog out.
d/ Where can you go on your own - own road, to school, to the local shops, on buses to the town centre (Enfield).

4/ Non directive questions - related to the problems of being a pedestrian. (See section 4.1.1).

a/ What do you like about walking?
b/ What don't you like about walking?

5/ Critical incident questions - related to near misses and accidents crossing the road. (See section 4.1.2).

a/ Has anyone seen, heard about or been in an accident or near accident involving a pedestrian?
b/ Whose fault do you think it was?
c/ How do you think it could have been prevented?

6/ Focused questions - about pedestrian facilities. (See section 4.1.3).

a/ What help can you get crossing the road?
b/ Which help do you like?
c/ Which help don't you like?
d/ Which do you think is the safest/least safest?
e/ If you could have **anything** to help you cross the road what would you want?
f/ DRAW A PICTURE OF IT - each child explains their picture. (See section 4.1.5).

7/ Focused questions - about IPDs

a/ What about a machine/device that you carried around with you that told you whether or not it was safe to cross the road. What do you think it would be like?
b/ SIMPLE VERBAL DESCRIPTION GIVEN AND MODEL SHOWN OF A PORTABLE ACTIVE NON-SELECTIVE IPD. (See appendix 10 and 13).

i/ DRAW A PICTURE AND/OR MAKE UP A STORY OF A CHILD OUT ONE DAY WITH THIS DEVICE. - each child explains their picture, and
ii/ What will happen next? and
iii/ What happened before?
iv/ BUBBLE DRAWING GIVEN. (See section 4.1.2 and appendix 1).

c/ VERBAL DESCRIPTION GIVEN AND ARTIST'S IMPRESSION SHOWN OF A FIXED PASSIVE SELECTIVE STAND-ALONE IPD. (See appendix 12 and 8)

i/ Do you think that people would find it useful?

8/ RANKING TASK FORM - (See section 4.2.1 and appendix 2).

9/ DEBRIEFING - Any queries, questions or comments.

APPENDIX 16. TABLES OF THE MEAN RANK, RANK OF MEAN RANK AND RANGE OF RANKINGS FOR EACH OF THE FIVE SUB-SAMPLES INTERVIEWED

TABLE A - Adults aged 18-60.
TABLE B - Adults aged 65+.
TABLE C - Visually Restricted.
TABLE D - Parent of Children aged 5-9.
TABLE E - Children aged 10-14.

Table A. Adults Aged 18-60: Mean Rank, Rank of Mean Rank and Range of Rankings for Nine Pedestrian Facilities on Scales of Perceived Safety and Like of Use. n=15

PEDESTRIAN FACILITY	SCALE: Most safe-least safe 1 - 9			Like using most-least 1 - 9		
	Mean Rank	Rank of Mean Rank	Range of Rankings	Mean Rank	Rank of Mean Rank	Range of Rankings
Zebra Xing	5.2	6	3-8	4.3	4	2-6
Footbridge	2.4	1	1-6	3.7	3	1-8
Fixed IPD	6.4	7	1-9	6.6	8	1-9
Pelican	3.9	3	1-8	2.7	1	1-8
Refuge	7.0	8	3-9	5.5	6	2-8
School Xing	4.4	4	1-7	5.1	5	2-8
Portable IPD	8.1	9	4-9	8.1	9	5-9
Subway	5.0	5	1-9	5.5	6	1-9
Ped'ised St	2.8	2	1-8	3.5	2	1-9

Table B. Adults Aged 65+ : Mean Rank, Rank of Mean Rank and Range of Rankings for Nine Pedestrian Facilities on Scales of Perceived Safety and Like of Use. n = 18

PEDESTRIAN FACILITY	SCALE: Most safe-least safe. 1 - 9 (n=16)			Like using most-least 1 - 9 (n=15)		
	Mean Rank	Rank of Mean Rank	Range of Rankings	Mean Rank	Rank of Mean Rank	Range of Rankings
Zebra Xing	2.9	1	1-8	1.3	1	1-3
Footbridge	5.6	6	1-9	6.5	9	2-9
Fixed IPD	6.2	8	2-9	5.4	5	3-9
Pelican	3.8	2	1-8	3.1	2	1-8
Refuge	6.1	7	3-9	6.0	7	3-9
School Xing	4.4	4	2-8	5.3	4	2-9
Portable IPD	7.1	9	3-9	6.4	8	4-9
Subway	4.9	5	1-9	5.9	6	2-9
Ped'ised St	4.0	3	1-9	5.1	3	1-8

Table C. Visually Restricted: Mean Rank, Rank of Mean Rank and Range of Rankings for Nine Pedestrian Facilities on the Scale of Perceived Safety. n=15

PEDESTRIAN FACILITY	SCALE: Most safe-least safe. 1 - 9		
	Mean Rank	Rank of Mean Rank	Range of Rankings
Zebra Xing	4 8	5	2-8
Footbridge	6.0	7	1-9
Fixed IPD	5.9	6	1-9
Pelican	3.6	2	1-9
Refuge	7.7	9	5-9
School Xing	2.8	1	1-6
Portable IPD	4.6	4	1-9
Subway	6.7	8	2-9
Ped'ised St	3.6	3	1-7

Table D. Parents of Children Aged 5-9: Mean Rank, Rank of Mean Rank and Range of Rankings for Nine Pedestrian Facilities on a Scale of Perceived Safety for Their Child. n=12

PEDESTRIAN FACILITY	SCALE Most safe - least safe. 1 - 9		
	Mean Rank	Rank of Mean Rank	Range of Rankings
Zebra Xing	4.8	5	2-9
Footbridge	3.7	3	2-6
Fixed IPD	6.1	7	2-9
Pelican	4.0	4	1-7
Refuge	7.8	8	6-9
School Xing	3.3	2	1-6
Portable IPD	8.0	9	7-9
Subway	4.9	6	1-9
Ped'ised St	2.3	1	1-5

Table E. Children Aged 10-14: Mean Rank, Rank of Mean Rank and Range of Rankings for Nine Pedestrian Facilities on Scales of Perceived Safety and Like of Use. n=18

PEDESTRIAN FACILITY	SCALE Most safe-least safe. 1 - 9			Like using most-least 1 - 9		
	Mean Rank	Rank of Mean Rank	Range of Rankings	Mean Rank	Rank of Mean Rank	Range of Rankings
Zebra Xing	6.4	8	3-9	5.5	7	2-9
Footbridge	2.9	1	1-8	3.7	1	1-8
Fixed IPD	5.6	6	1-9	4.7	5	1-9
Pelican	4.7	5	1-9	4.6	3	1-9
Refuge	6.8	9	2-9	6.3	9	1-9
School Xing	5.7	7	2-8	5.9	8	1-9
Portable IPD	4.2	3	1-9	4.7	4	1-9
Subway	3.8	2	1-9	4.9	6	1-9
Ped'ised St	4.5	4	1-9	4.3	2	1-8

APPENDIX 17. RANKING AND INTERVIEW RESULTS FOR NINE PEDESTRIAN FACILITIES.

Rank of the Mean Rank for Each Sub Sample of Pedestrians and for the Whole Sample for Nine Pedestrian Facilities Scale of Percieved Safety.

PEDESTRIAN FACILITY	SCALE Most safe-least safe. 1 - 9					
	RANK OF THE MEAN RANK GROUP					
	Adult n = 15	Elderly n = 16	Vis.Res. n = 20	Parents n = 12	Children n = 18	All N = 81
Zebra Xing	6	1	5	5	8	5
Footbridge	1	6	7	3	1	4
Fixed IPD	7	8	6	7	6	7
Pelican	3	2	2	4	5	2
Refuge	8	7	9	8	9	9
School Xing	4	4	1	2	7	3
Portable IPD	9	9	4	9	3	8
Subway	5	5	8	6	2	6
Ped'ised St	2	3	3	1	4	1

APPENDIX 18. DESCRIPTIONS OF THE PROJECTIVE DRAWINGS OF 'SOMETHING TO HELP YOU CROSS THE ROAD' FOR THE YOUNGEST AND MIDDLE AGE BAND GROUPS OF CHILDREN AND VERBAL DESCRIPTIONS GIVEN BY THE OLDEST GROUP.

Group 1 Youngest.

1 People press a button and a strong gate stops cars.
2* A robot lollipop lady.
3 A policeman.
4* A ski-lift across the road.
5 Escalators up and over the road.
6 A power boosted lift over the road

Group 2 Middle Age Band.

1* A cage swings across the road.
2 Moving walkways rise from the ground.
3 A handle releases a stop sign to cars.
4 A lever changes the lights for 30 seconds to allow crossing.
5 A moving walkway across the road.
6 A moving walkway above the road.

Group 3 Oldest.

1 A camera to catch offenders.
2 A lazer beam that cars can't cross.
3 A lift across the road.

*denotes those drawings shown in figures 4-6.

Rank of the Mean Rank for the Adult, Elderly and Child Groups and for the Three Groups Combined for Nine Pedestrian Facilities on the Most/Least Like Using Scale.

PEDESTRIAN FACILITY	SCALE Most -Least Like Using 1 - 9 RANK OF THE MEAN RANK GROUP Adult n = 15	Elderly n = 15	Children n = 18	All N = 49
Zebra Xing	4	1	7	2
Footbridge	3	9	1	4
Fixed IPD	8	5	5	7
Pelican	1	2	3	1
Refuge	7	7	9	9
School Xing	5	4	8	6
Portable IPD	9	8	4	8
Subway	6	6	6	5
Ped'ised St	2	1	2	3

Zebra Crossings were particularly disliked and thought unsafe by children. Children reported that cars often did not stop for them. In contrast the elderly sample thought zebras most safe and liked in use. This may be because they are prepared to wait for the traffic to stop, and like the unlimited time it then allows them to cross the road. Visually restricted pedestrians were worried about knowing whether or not the traffic had really stopped. The adult group echoed this concern at zebras on wide roads. Vehicles that had stopped prevented pedestrians seeing other vehicles overtaking them and 'jumping' the crossing. The overall safety ranking shows that people thought zebras middle of the range for safety. However, the overall liking rating was in the top three facilities.

Footbridges were thought very safe by adults, children and parents, but not very safe by the visually restricted and elderly. This may be because one needs to be fairly able bodied to use footbridges. However, visually restricted pedestrians reported that footbridges did allow them to cross the road independently, although guide-dogs had difficulty negotiating the stairs. Rankings on like of use confirmed these views, with the energetic young most liking footbridges and the old least liking them. Adults noted the inconvenience involved in using them.

Overall safety and like of use rankings were around the middle of the range.

Pelican Crossings were unanimously liked and thought safe, according to the ranking task. However, several detrimental comments were made about their use. It was particularly the elderly group that complained about how complicated they were, and the short cross time available. The new Puffin crossings can now solve the latter of these problems. The adult sample commented that pelicans can be inconveniently and badly placed. The visually restricted group wanted more audible signals and pimpled paving at pelican crossings and traffic light controlled intersections.

Refuges were unanimously disliked and thought less safe in use than most other facilities. However, most groups recognised the convenience of refuges in the absence of other facilities. The visually restricted pedestrians did not feel that they could make use of this convenience because they could not be sure whether or not traffic was present.

School Crossings were thought less safe and less liked by the very people they were designed for, children. Parents, adults, and particulary the elderly and visually restricted group thought that school crossings were safe. Parents thought they were good for their children and the visually resticted thought that a person helping them increased their confidence in travelling. The oldest group of children seemed to dismiss the idea of using a school crossing. It was as if they felt that they had passed that stage. Overall rankings showed that school crossings were seen as quite safe but not liked as much in use.

Subways were thought particulary safe by the children, although all the groups that ranked on like of use, including children, only gave it a middle range ranking. All groups were aware of the non-vehicle dangers in using subways, and adults commented about their inconvenience. Visually restricted pedestrians recognised that this facility could help them have independent mobility. One of the elderly groups did not have any subways in their area, the other group did. The group that had access to them liked them least. Overall rankings showed subways to be middle range for safety and like of use.

Pedestrianised Streets were unanimously liked in use and thought safe. Overall rankings confirmed this. Interestingly, in the children's sample, it was found that perception of safety and like of use of pedestrianised streets increased with age. This may have been due to the older group having more independent travel exposure, particularly to pedestrianised streets.

APPENDIX 19. STORIES TOLD ABOUT THE PROJECTIVE DRAWINGS OF 'A CHILD OUT ONE DAY WITH A PORTABLE IPD' FOR THE YOUNGEST AND MIDDLE AGE BAND GROUPS OF CHILDREN AND VERDAL DESCRIPTIONS OF A PORTABLE IPD GIVEN BY THE OLDEST GROUP.

Group 1 Youngest.

1* Battery or solar powered with a light to show if it wasn't working. The child drops it, it breaks but still works. At home Dad fixes it.
2 A light shows if the batteries go or if it goes wrong and there is a volume knob. The child forgets to look when crossing the road, the volume automatically increases and they cross okay.
3 The child kept on fiddling about with it and didn't take any notice of it. They fell over, got up and then crossed okay.
4* Press button for use and waves come out. Two girls: an angel protects and a devil wants to get the girls run over. The devil tells the girl with the IPD not to use it but she does. The girl without the device gets run over.
5* Solar powered with a bleep if it's not going to work. A girl with her new device talks and laughs with a boy. She is just about to walk into the road and the device tells her not to.
6 Device in the child's pocket, runs on solar power.

Group 2 Middle Age Band.

1 The child presses the button on it to cross and see a friend on the other side of the road.
2* Brightly coloured so you remember it. Two boys: one used it and was 'a good boy',the other did not and was 'a bad boy' and he got run over.
3 Boy thinks the IPD has signalled a car to stop on a busy road, but the boy had forgotten it and got run over.
4 A boy took it out but all the roads were clear, next day he forgot it and got hit by a car.
5* The device told a little girl of 7 to stop, she ignored it and ran to a friend.
6 A boy crosses at the traffic lights and the IPD makes the light turn red for the motorist.

Group 3 Oldest Group.

1 Hand held.
2* Digital, credit card size with a visual and auditory signal.
3 Like a watch, press button to cross, barrier comes down to stop cars, bleeps when you can cross.
4 An antenna points in different directions according to the traffic flow.
5 TV remote control size, press button according to traffic flow.
6 Automatic with no buttons to press, green is safe and red is stop.
7 Pocket size and works with a lazer.

*denotes those drawings shown in figures 7-12.

Table D. Children Aged 10-14: Bubble Drawing Comments to the Question 'What We Really Need is One of Those Pedestrian Devices'

NEGATIVE

2 Well I think a pedestrian crossing would do the job just as well.
2 If only there was a subway here we would have been there in seconds, but with a device you'll have to wait.
3 I don't want one they're silly.
3 No way, the traffic will stop in a minute anyway.
3 Shut up! You must be joking, just trust yourself you wally.
3 Be pasent (patient)

NEUTRAL

2 Yea, but can we rely on it? It will probably be safer.
3 Maybe, but they'll never make any difference because the risk would be the same.

POSITIVE

1 Yes, but we haven't got enough money.
1 Yes, they get you across SAFELY.
1 That's good let's go and get one.
1 You're right, we really need one before an accident.
1 Yes we do, there are too many cars and someone could get run over.
1 There's a shop what sell those devices, we can go and get one.
2 But I got one today. When do you get yours?
2 But they are only exclusive to rich people, not to us yet.
2 Yes, something that is easy to use and not complicated. Something that's here all the time.
3 Yea, it would help wouldn't it.
3 Yes, I know.

1 = 10-11 years old
2 = 11-12 years old.
3 = 13-14 years old.

APPENDIX 20. TABLES OF THE NEGATIVE, NEUTRAL AND POSITIVE BUBBLE DRAWING COMMENTS MADE BY THE ADULT, ELDERLY, PARENT AND CHILD SUB-SAMPLES.

TABLE A - Adults aged 18-60.
TABLE B - Adults aged 65+.
TABLE C - Parents of Children aged 5-9.
TABLE D - Children aged 10-14.

Table A. Adults aged 18-60: Bubble Drawing Comments to the Question 'What We Really Need is One of Those Pedestrian Devices'

NEGATIVE

If only it could stop the traffic for us.
Yes, but I'd have lost mine by now.
What's wrong with our eyes?
Battery flat!
Well I'm not sure about all this new fangled technology actually. I wouldn't really put all my trust in it. I would sooner judge myself.
No thanks, I want to live until I'm 60.
But they are so expensive we couldn't afford one. Anyway, the traffic is so heavy it would never let us cross.
I prefer my own eyes and ears.
You've got to be joking.

NEUTRAL

Yes, but how much do they cost?
What a car?
Maybe, but invent one first.

POSITIVE

I know, the traffic is so dangerous there could easily be an accident.
Yes, we do.

Table B. Elderly Aged 65+ : Bubble Drawing Comments to the Question 'What We Really Need is One of Those Pedestrian Devices'

NEGATIVE

An underpass would be essential.
You can never be sure when its really safe to cross the road.

NEUTRAL

What will the driver do, can he wait.
The green light should stay on longer.
Please can I have the green light longer
Please can I have the green light longer.
How can I safely cross the road?
If it is fool proof perhaps.
This would be a great help if the traffic was not heavy.
What I need is a pair of skates.

POSITIVE

They will wait until someone is killed then we will get one.
I think so, don't you.
Yes, I think they are very helpful.
This one, really helpful.
Yes, a good idea, I would like one of those.
Yes
Yes
Yes

Table C. Parents of Children Aged 5-9: Bubble Drawing Comments to the Question 'What We Really Need is One of Those Pedestrian Devices'

NEGATIVE

I wouldn't like a zebra coming shopping with me.
I wouldn't like to trust your life to a pedestrian device that could go wrong.
Oh! I know what you mean, its called a mummy.
I'd rather use my eyes and ears than rely on a gadget.

NEUTRAL

What a lollipop lady.
Get one and see how it would work round here.
A pelican crossing would be a good thing
What are they. I've never heard of them.
A policeman!
No, we will close our eyes and run like we normally do.

POSITIVE

Yes that sounds like a good idea but would you use it properly?
That would probably be a good idea but are the Council likely to install one?

APPENDIX 21. NUMBER OF INTERVIEWEES IN EACH SUB-SAMPLE REPORTING DIFFERENT LOWEST ACCEPTABLE PERCENTAGES OF ACCURACY FOR A PORTABLE IPD IN THE FOLLOW UP QUESTIONNAIRE. N=63

	Percentage of Accuracy Required						
Sub-sample	90%	95%	99%	99.99%	100%	No Resp	Total
Adults	2	1	2	1	7	2	15
Aged 65+	2	6	3	0	3	4	18
Vis. Res.	0	2	5	0	11	2	20
Parents	0	0	1	1	7	1	10
Totals	4	9	11	2	28	9	63

APPENDIX 22. KRUSKALL-WALLIS Z VALUES FOR EACH SUB-SAMPLE'S RANKINGS OF THE PORTABLE IPD ON THE SCALES OF PERCEIVED SAFETY AND LIKE OF USE.

Sub-Sample	Scale	
	Perceived Safety	Like of Use
Adults	3.22	3.99
Elderly	1.25	-0.38
Visually Restricted (less independent)	-4.11	n/a
Visually Restricted (more independent)	0.24	n/a
Parents	2.18	n/a
Children aged 10-11	-3.60	-3.56
Children aged 11-12	-2.38	-2.02
Children aged 13-14	1.20	0.55

APPENDIX 23. THE PERCENTAGE OF RESPONDENTS IN THE ADULT, ELDERLY, VISUALLY RESTRICTED AND PARENT SUB-SAMPLES THAT ANSWERED YES, PERHAPS AND NO WHEN ASKED IF THE PORTABLE IPD MIGHT BE USEFUL TO VARIOUS GROUPS OF PEDESTRIANS IN THE FOLLOW-UP QUESTIONNAIRE. N=63

GROUP ASSESSED	RESPONSE	GROUP RESPONDING				
		Adult n=15	65+ n=18	Vis.Res. n=20	Parents n=10	Total
	Yes	0	39	45	10	94
Self	Perhaps	0	28	40	30	98
	No	100	33	15	60	208
	Yes	27	44	50	50	171
Elderly	Perhaps	33	22	30	40	125
	No	40	33	20	10	103
	Yes	7	22	45	40	114
Children	Perhaps	13	* 17	15	50	95
	No	80	56	40	10	186
	Yes	60	56	50	50	216
Vis.Res.	Perhaps	20	22	* 35	30	107
	No	20	22	10	20	72
	Yes	33	50	30	20	133
Phys.Res.	Perhaps	7	* 17	40	50	114
	No	60	28	30	30	148
People	Yes	13	39	25	20	97
in	Perhaps	40	17	* 20	40	117
general	No	47	44	50	40	181

* Total is not 100% due to a non responses. There were 6 questions and 63 respondents (6 x 63 = 378 responses) and only four questions were not answered.

NB. Some totals do not reach 100% due to rounding.

APPENDIX 24. DIFFERENCES BETWEEN THE ADULT, ELDERLY, VISUALLY RESTRICTED AND PARENT SUB-SAMPLES IN THE ASSESSMENT OF THE USEFULNESS OF THE PORTABLE IPD FOR THE SIX GROUPS ASSESSED: KRUSKAL-WALLIS H VALUES WITH THE CORRESPONDING Z VALUES AND THE LEVEL OF SIGNIFICANCE

GROUP ASSESSED	H VALUES	Z VALUES		LEVEL OF SIGNIFICANCE
Self	24.66	Adult	-3.99	$p < .001$
		Elderly	1.44	
		Vis.Res.	3.09	
		Parents	-1.06	
Elderly	2.48	Adult	-1.15	not sig.
		Elderly	0.12	
		Vis.Res.	1.24	
		Parents	-0.39	
Children	9.37	Adult	-1.94	$p < .05$
		Elderly	-1.07	
		Vis.Res.	1.30	
		Parents	1.92	
Visually Restricted	1.54	Adult	-0.43	not sig.
		Elderly	-0.17	
		Vis.Res.	-0.30	
		Parents	1.09	
Physically Restricted	2.26	Adult	-1.21	not sig.
		Elderly	0.98	
		Vis.Res.	0.39	
		Parents	-0.30	
People in General	1.72	Adults	-0.90	not sig.
		Elderly	0.97	
		Vis.Res.	-0.35	
		Parents	0.30	

NB H values were adjusted for ties. Without adjustment the levels of significance remain in the same category.

APPENDIX 25. DIFFERNCES IN THE ASSESSMENT OF USEFULNESS OF THE PORTABLE IPD FOR THE SELF, ELDERLY, CHILDREN, VISUALLY RESTRICTED, PHYSICALLY RESTRICTED AND PEOPLE IN GENERAL GROUPS: FRIEDMAN TEST ESTIMATED MEANS AND SUM OF RANKS. N=63

GROUP ASSESSED	ESTIMATED MEDIAN	SUM OF RANKS
Self	1.0000	197.0
Elderly	1.0000	234.0
Child	1.0000	203.0
Visually Restricted	1.1667	277.0
Physically Restricted	1.0000	219.5
People in General	0.8333	192.5

APPENDIX 26. KRUSKALL-WALLIS Z VALUES FOR EACH SUB-SAMPLE'S RANKINGS OF THE FIXED IPD ON THE SCALES OF PERCEIVED SAFETY AND LIKE OF USE.

SUB-SAMPLE	SCALE	
	Perceived Safety	Like of Use
Adults	0.58	1.79
Elderly	0.09	0.05
Visually Restricted	-0.13	n/a
Parents	-0.19	n/a
Children aged 10-11	-3.73	-3.08
Children aged 11-12	1.58	-1.01
Children aged 13-14	1.62	1.49

APPENDIX 27. DATA COLLECTED ON PEDESTRIAN CROSSING MOVEMENTS FROM THE VIDEO OBSERVATIONS.

WEATHER 1 = dry, 2 = wet, 3 = raining, 4 = fog.

DIRECTION OF CROSSING 1 = from north or east, 2 = from south or west.

ACCOMPANIED by other person(s) 1 = no, 2 = yes.

WITH CHILDREN holding hands. 1 = no, 2 = yes.

PUSH CHAIR/PRAM/TROLLEY 1 = no, 2 = yes.

HEAVY/AWKWARD BAGGAGE/DOG eg. more than two carriers 1 = no, 2 = yes.

PEDESTRIAN VISIBILITY 1 = good, 2 = fair, 3 = bad. e.g. parked vehicles and congestion.

MOVES INTO ROAD before starting to cross 1 = no, 2 = yes.

MOVES ALONG KERB ROAD before starting to cross 1 = no, 2 = yes.

FORCED CROSSING 1 first leg of crossing 1 = no, 2 = yes.

VEHICLE TYPE 1 that pedestrian crossed in front of on first leg. 1 = 2 wheeler, 2 = car, 3 = van, 4 = lorry/bus. No vehicle registered if the pedestrian walks approximately 10 metres on the other side of the road before the next vehicle arrives.

MOVES ALONG CENTRE LINE 1 = no, 2 = yes in nearside traffic direction, 3 = yes in farside traffic direction.

FORCED CROSSING 2 second leg of crossing 1 = no, 2 = yes.

VEHICLE TYPE 2 that pedestrian crossed in front of on second leg 1 = 2 wheeler, 2 = car, 3 = van, 4 = lorry/bus. No vehicle registered if the pedestrian walks approximately 10 metres on the other side of the road before the next vehicle arrives.

TRAFFIC FLOW 1 from north or east per hour, readings taken in 5 minute intervals.

TRAFFIC FLOW 2 from south or west per hour, readings taken in 5 minute intervals.

PEDESTRIAN FLOW 1 on north or east pavement, readings taken in 5 minute intervals.

PEDESTRIAN FLOW 2 on south or west pavement, readings taken in 5 minute intervals.

PEDESTRIAN CROSSING FLOW 1 on reaching the north or east pavement, readings taken in 5 minute intervals.

PEDESTRIAN CROSSING FLOW 2 on reaching the south or west pavement, readings taken in 3 minute intervals.

PEDESTRIAN AGE GROUP 1 = 0-14, 1 = 15-59, 3 = 60+

PEDESTRIAN SEX 1 = female, 2 = male.

PEDESTRIAN DISABILITY EG. white stick or crutches 1 = no, 2 =yes.

CROSSING ANGLE 1 first leg of crossing. 1 = upto 15 degrees from 90, 2 = 16-30 degrees from 90, 3 = 31 -45 degrees from 90, 4 = > 45 degrees from 90.

CROSSING ANGLE 2 second leg of crossing.

UPSTREAM SPEED 1 speed of vehicle pedestrian crossed in front 50 metres before the crossing point on the first leg of crossing.

CROSS PLACE SPEED 1 speed of vehicle pedestrian crossed in front of at the place the pedestrian crossed on the first leg of crossing.

UPSTREAM SPEED 2 as above but for the second leg of crossing.

CROSS PLACE SPEED 2 as above but for the second leg of crossing.

KERB/ROAD WAIT TIME time from making observable cues to impending crossing eg. head movements to starting to cross.

TIME TO MIDWAY time from starting to cross (only if from the kerb) to reaching midway.

MIDWAY WAIT TIME time from reaching midway to leaving midway.

SECOND LEG TIME time from leaving midway to reaching the kerb.

TOTAL UNBROKEN CROSSING TIME time spent travelling from kerb to kerb. (no midway waits)

ACCEPTED GAP OR LAG 1 time from pedestrian starting to cross to when the vehicle that the pedestrain crossed in front of reaches the place where the pedestrian crossed on the first leg of crossing.

ACCEPTED GAP OR LAG 2	time from pedestrian leaving midway to when the vehicle that the pedestrian crossed in front of reaches the place where the pedestrain crossed on the second leg of crossing

APPENDIX 28. THE AMOUNT OF DATA COLLECTED AT EACH SITE IN THE OBSERVATIONAL STUDY OF PEDESTRIAN CROSSING MOVEMENTS.

The amount of data in the following categories is shown:

A - the time of day when the pedestrian crossings took place

B - the length of time pedestrian crossings were analysed

C - the number of pedestrian crossing observations collected with:

C1 - basic information about the environment and circumstances of the pedestrian him/herself

C2 - pedestrian and vehicle flows

C3 - details of the pedestrian's age group

C4 - details of the pedestrian's approximate angle of crossing

C5 - information about the speed of vehicles that interacted with pedestrians

C6 - crossing and wait times, and gaps/lags accepted.

A Site/Time of Day	B Length of Time Anal.	C1 basic data	C2 ped/veh flows	C3 age	C4 ped angle	C5 veh speeds	C6 wait/gap + lags
	hours/mins		number of observations				
Tottenham Saturday 11-12am	1.05	138	138	137	129	10	134
Tottenham Monday 11-11.35am	35	74	74	74	62	7	74
Station Rd 7.30-9.45am	2.15	238	238	238	205	48	231
Willow Rd							
11-12am	55	24	0	24	1	14	0
3-5.25pm	2.25	80	80	80	79	40	79
Lancaster Rd							
10.15-12am	1.45	180	180	180	177	57	176
12-1+2-3.20pm	2.20	133	133	99	132	51	0
3.20-3.45pm	25	39	39	38	39	13	0
Total (max=906)	11.45	906	882	870	824	240	694

APPENDIX 29. VEHICLE FLOW, PEDESTRIAN FLOW AND PEDESTRIAN CROSSING FLOW: MINIMUM, MAXIMUM, MEAN AND FLOW INDICES FOR EACH SITE AND DAY.

Site/Day	Veh Flow min (each 5m)	Veh Flow max (each 5m)	Veh Flow mean (per hour)	VFI (per hour)	Ped Flow min (each 5m)	Ped Flow max (each 5m)	Ped Flow mean (p/h)	Ped X Flow min (each 5m)	Ped X Flow max (each 5m)	Ped X Flow mean (per hr)	PFI (per hr)
Tottenham Saturday	43	190	1124	94.3	89	230	1675	8	41	322	8.5
Tottenham Monday	59	104	967	81.1	90	125	1303	5	21	176	4.6
Station Road	45	129	1050	150.4	6	61	340	0	50	196	3.9
Willow Road	71	156	1297	89.7	3	27	145	1	10	56	0.8
Lancaster Road	20	112	952	126.1	14	63	387	0	24	145	1.7

APPENDIX 30. MINIMUM, MAXIMUM, MEAN AND NUMBER OF KERB/ROAD WAIT TIMES FOR EACH SITE AND FOR ALL SITES TOGETHER AND THE MIDWAY WAIT TIMES FOR ALL SITES.

Site/Day	no.	Kerb/Road Wait min	max	mean
Tottenham Saturday	55	0.4	68.2	6.8
Tottenham Monday	19	0.6	77.1	7.7
Station Rd	170	0.0	59.1	6.0
Willow Rd	57	0.8	127.2	14.8
Lancaster Rd	120	0.7	84.1	11.0
All Sites	421	0.0	127.2	8.8
		Midway Wait		
All Sites	36	0.7	10.8	4.7

NB. It should be noted that although there were 694 observations made of potential midway wait times, there were only 36 (5.2%) actual midway waits. The figures given in table 37 only include these 36 observations.

APPENDIX 31. NUMBER AND PERCENTAGE OF PEDESTRIANS CROSSING THE FIRST AND SECOND LEG OF THE ROAD USING VARIOUS CATEGORIES OF CROSSING ANGLE.

Site/Day		<15	Degrees away from 90 16-30	31-45	>45	Total
Tottenham Saturday	leg1	117 90.7%	4 3.1%	5 3.9%	3 2.3%	129
	leg2	104 80.6%	10 7.8%	9 7.0%	6 4.7%	131
Tottenham Monday	leg1	40 64.5%	10 16.1%	10 16.1%	2 3.2%	62
	leg2	39 63.9%	9 14.8%	12 19.7%	1 1.6%	61
Station Rd	leg1	149 72.7%	39 19.0%	16 7.8%	1 0.5%	205
	leg2	145 70.7%	42 20.5%	17 8.3%	1 0.5%	205
Willow Rd	leg1	79 98.8%	1 1.2%	0 0	0 0	80
	leg2	76 95.0%	2 2.5%	1 1.3%	1 1.3%	80
Lancaster Rd	leg1	271 77.7%	28 8.0%	15 4.3%	35 10.0%	349
	leg2	222 63.6%	48 13.8%	23 6.6%	56 16.0	349
All Sites	leg1	656 79.5%	82 9.9%	46 5.6%	41 5.0%	825
	leg2	586 71.3%	111 13.5%	62 7.0%	65 7.4%	824

APPENDIX 32. MINIMUM, MAXIMUM, MEAN AND NUMBER OF OBSERVATIONS OF TIME TO MIDWAY, SECOND LEG CROSSING TIME, TOTAL UNBROKEN CROSSING TIME AND CROSSING SPEEDS IN METRES PER SECOND FOR EACH SITE AND FOR ALL SITES.

Site/Day		no.	min	max	mean
Tottenham Saturday	Time to midway	92	2.2	10.5	4.6
	2nd leg X time	101	1.6	9.7	4.9
	Total X time	67	4.9	16.7	9.6
	X speed 1	87	.6	2.7	1.5
	X speed 2	92	.6	3.7	1.4
Tottenham Monday	Time to midway	42	2.5	9.6	5.2
	2nd leg X time	69	2.4	8.4	5.5
	Total X time	39	6.9	16.8	10.7
	X speed 1	36	.7	2.6	1.4
	X speed 2	57	.8	2.5	1.2
Station Rd	Time to midway	216	.8	4.8	2.2
	2nd leg X time	229	1.0	6.1	2.6
	Total X time	214	1.2	10.1	4.8
	X speed 1	187	.6	3.7	1.6
	X speed 2	199	.5	3.0	1.3
Willow Rd	Time to midway	53	2.1	9.1	4.7
	2nd leg X time	79	1.4	11.1	4.8
	Total X time	53	4.0	17.6	9.7
	X speed 1	53	.8	3.5	1.7
	X speed 2	79	.7	3.8	1.8
Lancaster Rd	Time to midway	123	1.4	6.6	2.9
	2nd leg X time	163	1.5	8.2	3.5
	Total X time	111	3.0	14.1	6.5
	X speed 1	123	.6	3.4	1.5
	X speed 2	162	.7	2.6	1.3
All Sites	Time to midway	526	.8	10.5	3.3
	2nd leg X time	641	1.0	11.1	3.8
	Total X time	484	1.2	17.6	6.8
	X speed 1	486	.6	3.7	1.5
	X speed 2	589	.5	5.2	1.4

APPENDIX 33. MINIMUM,MAXIMUM, MEAN AND NUMBER OF OBSERVATIONS FOR THE UPSTREAM SPEED AND CROSS PLACE SPEED OF VEHICLES THAT INTERACTED WITH PEDESTRIANS FOR BOTH LEGS OF CROSSING COMBINED AT EACH SITE AND FOR ALL SITES.

Site/Day	no. Speed		min Speed		max Speed		mean Speed	
	U/S	at X	U/S	at X	U/S	at X	U/S	at X
Tottenham Saturday	10	10	7	8	32	29	20.0	17.5
Tottenham Monday	7	7	10	5	26	19	15.5	12.5
Station Rd	48	48	8	6	26	29	16.1	14.4
Willow Rd	54	54	10	10	41	38	29.7	27.1
Lancaster Rd	121	121	0	0	32	31	23.6	20.4
All Sites 1	240	240	0	0	41	38	23.0	20.3

U/S = Upstream speed in miles per hour.
at X = Cross place speed in miles per hour.

APPENDIX 34. MINIMUM, MAXIMUM, MEAN AND NUMBER OF OBSERVATIONS OF GAPS ACCEPTED AND SAFETY MARGINS, FOR BOTH LEGS OF CROSSING, FOR EACH SITE AND FOR ALL SITES.

Site/Day		no.		min		max		mean	
		Gaps	S/M	Gaps	S/M	Gaps	S/M	Gaps	S/M
Tottenham	leg1	46	33	2.2	-1.9	22.1	17.3	8.5	4.6
Saturday	leg2	29	28	2.0	-2.1	9.9	3.9	4.6	0.3
Tottenham	1	20	12	2.1	0.0	14.4	12.7	7.5	3.7
Monday	2	19	19	2.3	-3.3	12.3	7.1	5.0	-0.5
Station Rd	1	156	149	2.0	-2.9	15.4	9.8	6.4	4.4
	2	103	103	0.8	-1.3	12.3	9.3	5.3	3.0
Willow Rd	1	51	29	3.3	0.5	14.7	13.4	7.2	3.0
	2	53	53	2.1	-4.0	10.1	4.8	5.1	0.6
Lancaster Rd	1	70	46	2.5	-0.1	16.7	9.3	7.6	4.8
	2	87	84	1.2	-4.5	12.5	9.3	5.3	1.9
All Sites	1	343	269	2.0	-2.9	22.1	17.3	7.1	4.3
	2	291	287	0.8	-4.5	12.5	9.3	5.2	1.7

S/M = Safety Margin.
NB. Gaps and safety margins are measured in seconds.

APPENDIX 35. NUMBER OF OBSERVATIONS, MEAN GAP ACCEPTED AND SAFETY MARGINS FOR BOTH LEGS OF CROSSING, FOR EACH AGE AND SEX GROUP.

Leg		Age	Sex					
			Female		Male		All	
			gap	S/M	gap	S/M	gap	S/M
	1	0-14	7	4	11	10	18	14
			8.4	7.0	7.0	3.8	7.6	4.7
Leg 1	2	15-59	130	99	163	137	293	236
			7.3	4.5	6.3	4.1	7.0	4.3
	3	60+	17	10	15	9	32	19
			8.0	4.5	7.9	4.7	7.9	4.6
		Total	154	113	189	156	343	269
			7.4	4.6	6.9	4.1	7.1	4.3
	1	0-14	6	6	10	10	16	16
			6.5	3.7	4.0	0.6	5.0	1.7
Leg 2	2	15-59	111	108	128	127	239	235
			5.2	1.8	5.1	1.8	5.2	1.8
	3	60+	22	22	14	14	36	36
			4.7	0.5	5.9	2.1	5.2	1.1
		Total	139	136	152	151	291	287
			5.2	1.7	5.1	1.8	5.6	1.7

gap = mean gap accepted
S/M = mean safety margin

APPENDIX 36. RESULTS OF THE REGRESSION ANALYSES FOR THE FIRST AND SECOND LEG GAP ACCEPTED.

KEY:

accno	=	not accompanied
visgood	=	visibility good
visfair	=	visibility fair
2wheel1 2wheel2	=	2 wheel vehicle on the first/second leg of crossing
car1 car2	=	car on the first/second leg of crossing
van1 van2	=	van on the first/second leg of crossing
0-14 15-59 60+	=	age group
female	=	sex
kw	=	kerb wait
midw	=	midway wait
vf	=	vehicle flow
pedflo1 pedflo2	=	pedestrian flow on the nearside/farside footway
pedxflo	=	pedestrian crossing flow
plm/s1 plm/s2	=	pedestrian crossing flow in metres per second on the first/second leg of crossing
encumber	=	pedestrian encumbered

```
Stepwise Regression

 F-to-Enter: 100000.00    F-to-Remove:       4.00

 Response is   gap1   on 15 predictors, with N =   166
 N(cases with missing obs.) = 740 N(all cases) =   906

    Step          1        2        3        4        5        6        7
Constant      6.381    6.416    6.472    6.847    7.376    6.514    5.785

accno          1.85     1.85     1.83     1.83     1.84     1.90     1.87
T-Ratio        2.49     2.51     2.51     2.51     2.53     2.61     2.57

visgood         4.3      4.3      4.3      4.3      4.1      4.3      4.6
T-Ratio        1.57     1.58     1.58     1.57     1.51     1.57     1.68

visfair         5.2      5.2      5.2      5.2      5.0      5.1      5.4
T-Ratio        1.85     1.86     1.88     1.85     1.80     1.85     1.96

2whhel1         0.7      0.7      0.8
T-Ratio        0.38     0.38     0.42

car1          -2.32    -2.32    -2.29    -2.64    -2.73    -2.77    -2.73
T-Ratio       -1.80    -1.80    -1.79    -2.75    -2.86    -2.89    -2.84

van1           -2.5     -2.5     -2.5     -2.8     -3.0     -3.0     -3.0
T-Ratio       -1.77    -1.78    -1.77    -2.57    -2.73    -2.81    -2.78

0-14            2.9      2.8      2.9      2.8      2.8      3.5      3.4
T-Ratio        2.32     2.33     2.37     2.36     2.29     3.40     3.32

15-59         -0.83    -0.83    -0.83    -0.81    -0.81
T-Ratio       -1.24    -1.25    -1.25    -1.22    -1.22

female         0.35     0.35     0.36     0.38
T-Ratio        0.87     0.89     0.90     0.96

kw           -0.036   -0.036   -0.035   -0.035   -0.034   -0.031
T-Ratio       -1.46    -1.46    -1.45    -1.47    -1.44    -1.30

vflow         0.003    0.002
T-Ratio        0.22     0.21

pedflo1       0.015    0.016    0.015    0.016    0.015    0.016    0.019
T-Ratio        1.06     1.27     1.26     1.28     1.23     1.32     1.56

pedxflo       0.002
T-Ratio        0.05

p1m/s         -2.02    -2.02    -2.01    -2.00    -2.05    -2.11    -2.00
T-Ratio       -5.06    -5.09    -5.11    -5.11    -5.29    -5.48    -5.32

encumber       2.00     2.00     1.99     1.97     2.04     2.10     2.07
T-Ratio        2.59     2.60     2.60     2.59     2.70     2.77     2.73

S              2.46     2.45     2.44     2.44     2.44     2.44     2.45
R-Sq          34.38    34.38    34.36    34.28    33.89    33.24    32.52
 More? (Yes, No, Subcommand, or Help)
SUBC> yes

    Step          8        9       10
Constant      6.316   10.673   10.830

accno          1.96     1.84     1.94
T-Ratio        2.68     2.52     2.64

visgood         4.3
```

```
T-Ratio       1.57

visfair       5.58      1.41
T-Ratio       2.01      1.73

2whhel1
T-Ratio

car1         -2.67     -2.75     -2.85
T-Ratio      -2.77     -2.85     -2.94

van1          -2.9      -3.0      -3.1
T-Ratio      -2.67     -2.76     -2.84

0-14          3.27      2.73      2.83
T-Ratio       3.17      2.79      2.88

15-59
T-Ratio

female
T-Ratio

kw
T-Ratio

vflow
T-Ratio

pedflo1
T-Ratio

pedxflo
T-Ratio

p1m/s        -2.03     -1.96     -2.00
T-Ratio      -5.39     -5.21     -5.31

encumber      2.02      1.80      1.91
T-Ratio       2.66      2.40      2.53

S             2.46      2.47      2.48
R-Sq         31.47     30.39     29.08
 More? (Yes, No, Subcommand, or Help)
SUBC> no
MTB > Stepwise 'gap2' 'accno' 'visgood' 'visfair' '2wheel2'-'van2' '0-14' &
CONT>      '15-59' 'female' 'midw' 'vflow2' 'pedflo2'  'pedxflo' 'p2m/s'   &
CONT>      'encumber';
SUBC>   Enter 'accno' 'visgood' 'visfair' '2wheel2'-'van2' '0-14' '15-59'  &
CONT>      'female' 'midw' 'vflow2' 'pedflo2' 'pedxflo' 'p2m/s' 'encumber';
SUBC>   FEnter 100000;
SUBC>   FRemove 4.0.

Stepwise Regression


 F-to-Enter: 100000.00    F-to-Remove:       4.00

 Response is   gap2   on 15 predictors, with N =  261
 N(cases with missing obs.) = 645 N(all cases) =  906

   Step          1         2         3         4         5         6         7
Constant     7.973     7.970     7.939     7.913     8.027     7.984     8.033

accno         0.10      0.10      0.10      0.10
T-Ratio       0.26      0.26      0.26      0.26

visgood      -1.40     -1.40     -1.40     -1.40     -1.42     -1.43     -1.37
T-Ratio      -1.95     -1.96     -1.96     -1.96     -2.00     -2.03     -1.96
```

visfair	-1.22	-1.22	-1.22	-1.22	-1.23	-1.24	-1.25
T-Ratio	-1.64	-1.65	-1.65	-1.66	-1.67	-1.69	-1.70
2wheel2	0.56	0.57	0.60	0.60	0.60	0.68	
T-Ratio	0.64	0.65	0.79	0.79	0.79	0.95	
car2	-0.13	-0.13	-0.10	-0.10	-0.10		
T-Ratio	-0.24	-0.24	-0.31	-0.30	-0.29		
van2	-0.05	-0.05					
T-Ratio	-0.08	-0.07					
0-14	1.26	1.26	1.26	1.27	1.25	1.25	1.28
T-Ratio	1.88	1.89	1.89	1.91	1.89	1.90	1.95
15-59	0.84	0.85	0.84	0.84	0.85	0.85	0.85
T-Ratio	2.04	2.05	2.06	2.06	2.08	2.09	2.09
female	-0.03	-0.03	-0.03				
T-Ratio	-0.12	-0.12	-0.13				
midw	-0.188	-0.187	-0.188	-0.188	-0.191	-0.192	-0.196
T-Ratio	-2.30	-2.30	-2.32	-2.32	-2.41	-2.42	-2.49
vflow2	0.0136	0.0134	0.0134	0.0134	0.0135	0.0132	0.0116
T-Ratio	1.25	1.33	1.34	1.34	1.35	1.33	1.19
pedflo2	-0.0089	-0.0092	-0.0092	-0.0091	-0.0095	-0.0093	-0.0083
T-Ratio	-1.06	-1.40	-1.41	-1.40	-1.52	-1.50	-1.36
pedxflo	-0.001						
T-Ratio	-0.05						
p2m/s	-1.74	-1.74	-1.74	-1.74	-1.74	-1.75	-1.77
T-Ratio	-6.16	-6.19	-6.20	-6.22	-6.27	-6.35	-6.42
encumber	0.53	0.53	0.53	0.52	0.53	0.52	0.59
T-Ratio	1.11	1.11	1.11	1.11	1.12	1.10	1.26
S	2.00	2.00	1.99	1.99	1.98	1.98	1.98
R-Sq	19.89	19.88	19.88	19.88	19.86	19.83	19.54

More? (Yes, No, Subcommand, or Help)
SUBC> yes

Step	8	9	10	11	12	13	14
Constant	8.466	8.651	8.474	8.702	8.821	7.722	7.575
accno							
T-Ratio							
visgood	-1.35	-1.41	-1.40	-1.39	-1.20		
T-Ratio	-1.92	-2.01	-1.99	-1.97	-1.75		
visfair	-1.29	-1.35	-1.47	-1.60	-1.49	-0.35	
T-Ratio	-1.77	-1.85	-2.02	-2.19	-2.06	-1.11	
2wheel2							
T-Ratio							
car2							
T-Ratio							
van2							
T-Ratio							
0-14	1.25	1.28	1.31				
T-Ratio	1.90	1.94	1.99				
15-59	0.89	0.87	0.82	0.36			

```
T-Ratio       2.20      2.15      2.02      1.07

female
T-Ratio

midw        -0.197    -0.192    -0.205    -0.187    -0.182    -0.187    -0.196
T-Ratio      -2.49     -2.43     -2.61     -2.38     -2.32     -2.37     -2.51

vflow2
T-Ratio

pedflo2    -0.0089   -0.0088
T-Ratio      -1.46     -1.44

pedxflo
T-Ratio

p2m/s        -1.73     -1.78     -1.74     -1.58     -1.58     -1.61     -1.56
T-Ratio      -6.32     -6.58     -6.47     -6.13     -6.13     -6.23     -6.12

encumber      0.54
T-Ratio       1.16

S             1.98      1.98      1.99      2.00      2.00      2.01      2.01
R-Sq         19.09     18.66     17.99     16.72     16.34     15.34     14.93
 More? (Yes, No, Subcommand, or Help)
SUBC>  yes

 No variables entered or removed

 More? (Yes, No, Subcommand, or Help)
SUBC> no
MTB > Name c73 = 'SRES1' c74 = 'FITS1'
MTB > Regress 'gap1' 6 'p1m/s' 'accno' 'car1' 'van1' '0-14' 'encumber';
SUBC>   SResiduals 'SRES1';
SUBC>   Fits 'FITS1';
SUBC>   Constant.

Regression Analysis


The regression equation is
gap1 = 11.5 - 2.14 p1m/s + 1.04 accno - 2.40 car1 - 2.32 van1 + 1.78 0-14
           + 1.94 encumber

236 cases used 670 cases contain missing values

Predictor         Coef         Stdev    t-ratio        p
Constant        11.534         1.129      10.22    0.000
p1m/s          -2.1416        0.3742      -5.72    0.000
accno           1.0411        0.6069       1.72    0.088
car1           -2.4002        0.7718      -3.11    0.002
van1           -2.3245        0.8983      -2.59    0.010
0-14            1.7759        0.8112       2.19    0.030
encumber        1.9413        0.6605       2.94    0.004

s = 2.773       R-sq = 20.9%     R-sq(adj) = 18.8%

Analysis of Variance

SOURCE          DF          SS          MS         F         p
Regression       6     465.533      77.589     10.09     0.000
Error          229    1760.519       7.688
Total          235    2226.052

SOURCE          DF      SEQ SS
p1m/s            1     236.893
accno            1      22.700
car1             1      18.584
```

van1	1	66.462
0-14	1	54.480
encumber	1	66.414

Unusual Observations

Obs.	p1m/s	gap1	Fit	Stdev.Fit	Residual	St.Resid
33	1.82	8.900	10.627	0.945	-1.727	-0.66 X
56	1.13	17.900	7.753	0.283	10.147	3.68R
72	1.28	*	8.803	0.972	*	* X
73	1.28	*	8.803	0.972	*	* X
89	0.59	*	12.052	1.252	*	* X
90	0.57	*	12.088	1.255	*	* X
120	1.25	22.100	7.501	0.258	14.599	5.29R
209	1.18	14.400	8.559	0.877	5.841	2.22RX
227	1.30	13.400	7.461	0.511	5.939	2.18R
252	2.01	11.400	5.873	0.268	5.527	2.00R
255	1.66	12.300	6.610	0.222	5.690	2.06R
273	3.75	2.000	2.154	0.831	-0.154	-0.06 X
381	2.92	5.700	6.318	0.881	-0.618	-0.23 X
390	1.66	2.900	8.627	0.795	-5.727	-2.16R
405	1.19	15.400	7.626	0.269	7.774	2.82R
479	2.14	9.000	6.331	0.846	2.669	1.01 X
480	1.96	9.100	6.702	0.843	2.398	0.91 X
481	1.05	13.700	7.994	0.537	5.706	2.10R
499	3.46	6.400	3.496	1.016	2.904	1.13 X
544	1.17	*	9.515	1.012	*	* X
549	3.03	*	5.464	0.869	*	* X
553	1.48	14.700	7.073	0.502	7.627	2.80R
557	1.65	*	7.541	0.888	*	* X
595	2.23	7.000	6.128	0.850	0.872	0.33 X
596	2.53	5.800	5.490	0.871	0.310	0.12 X
612	1.65	*	8.492	0.970	*	* X
615	0.63	16.700	10.761	0.698	5.939	2.21R
619	1.58	12.400	6.788	0.221	5.612	2.03R
629	1.46	3.800	9.449	0.753	-5.649	-2.12R
663	1.36	16.200	13.389	1.160	2.811	1.12 X
707	1.08	8.700	11.570	0.966	-2.870	-1.10 X
723	1.81	9.900	10.021	0.923	-0.121	-0.05 X

R denotes an obs. with a large st. resid.
X denotes an obs. whose X value gives it large influence.

MTB > plot c73 c74

Character Plot

```
          -                              *
      5.0+
          -
 SRES1    -
          -                               *
          -                            *  *
      2.5+
          -                         *  **   * * *   *    *
          -                      *  * 2*2   2** * *
          -            *         2**  42*4**2  *     2            *
          -         * *           * **22*3**43* *  *
      0.0+         *           2 *252349596443 3  2  ***
          -                     *23* 32439342* 22* **    *
          -                     * ***2232455     *         *
          -                         ** *52* 2     *  *
          -                              *     * **
     -2.5+
           --------+---------+---------+---------+---------+--------FITS1
                 2.5       5.0       7.5      10.0      12.5
       N* = 670
```

MTB > plo c46 c74

```
* ERROR * Unknown MINITAB command:  PLO

MTB > plot c46 c74

Character Plot

        -                          *
    21.0+
        -
 gap1   -                           *
        -                                     *          *
        -                         *  *
    14.0+                          * * *  **
        -                     ** . * * *    2
        -                  * * 2   2* *   *
        -               *  * ***3**2 * *   ***
        -               * *  44*43*65 3 *2**   * *
     7.0+          *    ** **27594522 22
        -               *3524563956*  *  *  *
        -      * *    2**2* 4*22633 2    **
        -              **2***3**33     *
        -     *
     0.0+
         --------+---------+---------+---------+---------+--------FITS1
                2.5       5.0       7.5      10.0      12.5
      N* = 670

MTB > Name c81 = 'SRES5' c82 = 'FITS5'
MTB > Regress 'gap2' 7 'visgood' 'visfair' '0-14' 'pedflo2'  'midw'  &
CONT>    'p2m/s' '15-59';
SUBC>   SResiduals 'SRES5';
SUBC>   Fits 'FITS5';
SUBC>   Constant.

Regression Analysis


The regression equation is
gap2 = 8.64 - 1.43 visgood - 1.28 visfair + 1.30 0-14 - 0.00941 pedflo2
           - 0.194 midw - 1.77 p2m/s + 0.902 15-59

264 cases used 642 cases contain missing values

Predictor       Coef       Stdev    t-ratio       p
Constant      8.6383      0.7736      11.17   0.000
visgood      -1.4337      0.7017      -2.04   0.042
visfair      -1.2838      0.7320      -1.75   0.081
0-14          1.3021      0.6518       2.00   0.047
pedflo2    -0.009406    0.006115      -1.54   0.125
midw        -0.19403     0.07930      -2.45   0.015
p2m/s        -1.7705      0.2695      -6.57   0.000
15-59         0.9017      0.3964       2.27   0.024

s = 1.990       R-sq = 18.6%     R-sq(adj) = 16.3%

Analysis of Variance

SOURCE       DF          SS          MS         F        p
Regression    7     231.089      33.013      8.34    0.000
Error       256    1013.565       3.959
Total       263    1244.654

SOURCE       DF      SEQ SS
visgood       1       3.363
visfair       1      17.145
0-14          1       2.431
pedflo2       1       5.999
```

midw	1	25.976
p2m/s	1	155.686
15-59	1	20.490

Unusual Observations

Obs.	visgood	gap2	Fit	Stdev.Fit	Residual	St.Resid
14	1.00	*	5.205	0.600	*	* X
15	1.00	*	4.166	0.600	*	* X
18	1.00	5.200	4.975	0.608	0.225	0.12 X
19	1.00	5.200	5.013	0.609	0.187	0.10 X
22	1.00	*	4.154	0.663	*	* X
51	0.00	2.500	2.511	0.821	-0.011	-0.01 X
52	0.00	2.000	2.414	0.855	-0.414	-0.23 X
85	0.00	*	4.135	0.789	*	* X
89	0.00	*	5.716	0.623	*	* X
90	0.00	*	3.335	0.666	*	* X
116	0.00	*	0.976	0.755	*	* X
134	1.00	4.400	3.535	0.628	0.865	0.46 X
155	1.00	12.300	5.567	0.265	6.733	3.41R
181	0.00	*	7.114	0.720	*	* X
182	0.00	*	7.421	0.725	*	* X
205	0.00	*	6.696	0.686	*	* X
235	1.00	0.800	5.430	0.153	-4.630	-2.33R
272	1.00	10.200	6.102	0.196	4.098	2.07R
329	1.00	9.300	5.275	0.150	4.025	2.03R
330	1.00	12.300	6.031	0.190	6.269	3.17R
363	1.00	9.900	4.469	0.194	5.431	2.74R
404	1.00	9.800	5.764	0.180	4.036	2.04R
479	1.00	4.200	4.243	0.692	-0.043	-0.02 X
480	1.00	4.200	4.282	0.682	-0.082	-0.04 X
482	1.00	5.300	4.442	0.620	0.858	0.45 X
486	1.00	4.700	2.873	0.600	1.827	0.96 X
499	1.00	3.800	1.704	0.711	2.096	1.13 X
500	1.00	3.100	2.882	0.600	0.218	0.11 X
515	1.00	8.900	4.920	0.186	3.980	2.01R
524	1.00	9.700	5.719	0.183	3.981	2.01R
532	1.00	3.100	2.853	0.813	0.247	0.14 X
550	1.00	*	2.141	0.742	*	* X
553	1.00	10.100	5.859	0.195	4.241	2.14R
561	0.00	2.100	4.791	0.771	-2.691	-1.47 X
573	0.00	3.900	6.106	0.609	-2.206	-1.16 X
576	0.00	11.400	6.289	0.344	5.111	2.61R
610	0.00	3.800	6.359	0.704	-2.559	-1.38 X
654	0.00	4.900	6.718	0.699	-1.818	-0.98 X
667	0.00	*	5.360	0.741	*	* X
668	0.00	6.300	6.808	0.705	-0.508	-0.27 X
681	0.00	4.000	7.261	0.700	-3.261	-1.75 X
684	0.00	12.500	7.371	0.800	5.129	2.82RX
687	0.00	*	7.339	0.701	*	* X
695	0.00	12.500	6.804	0.707	5.696	3.06RX
696	0.00	7.200	6.596	0.706	0.604	0.32 X
707	0.00	6.900	7.491	0.801	-0.591	-0.32 X
708	0.00	*	6.587	0.704	*	* X
723	0.00	*	5.970	0.604	*	* X
728	0.00	12.500	5.855	0.313	6.645	3.38R

R denotes an obs. with a large st. resid.
X denotes an obs. whose X value gives it large influence.

```
MTB >  plot c48 c82

Character Plot

          -                                        *       *   *
      12.0+                                     *   *
          -                                           *
  gap2    -                                        * *
          -                            *      *  *2  *
          -                                ***   ** *3
       8.0+                           *  2    23  *    2
          -                               *   3 *25 3** *2      *
          -                           2    *** 4* 2***4*2* *
          -                    2       * **2**363*** 2 **
          -            *  *    22     *2 232*52*623*3*22* *
       4.0+     *      *        * 2 ****3232 4432732*4**       *
          -               2  2 ** * 2**2*** 222*3 23 2
          -           **    * 2   32 *2*3 3       *
          -                             *      *
          -                                 *  *
       0.0+
            +---------+---------+---------+---------+---------+---------+------FITS5
          1.2       2.4       3.6       4.8       6.0       7.2
        N* = 642

MTB > plot c81 c82

Character Plot

          -                                     *
  SRES5   -                                        **      *
          -                            *              *        *
          -
       2.0+                                ** *  *2* 2
          -                           *  2  **3  ** **
          -     *      *       2          *   3   *  2
          -            *  *    *      2    *  * *24 2 *2
          -                    *2     *3 3*222 5* 3**** *2
       0.0+            *  2 *2 ** 2 ***   32*3453* ***3*2*
          -           *       2 * 2 2  2334* 422623 32 **  *    *
          -                       22 2223  *23522742*222  *
          -                           * * 2  * *3 23 4***
          -                             * *       ** *         *
      -2.0+                                 *  *
          -                                    *
          -
            +---------+---------+---------+---------+---------+---------+------FITS5
          1.2       2.4       3.6       4.8       6.0       7.2
        N* = 642
```